TECHNICAL REPORT

BRITISH COLUMBIA ENERGY SUPPLY AND REQUIREMENTS FORECAST 1978-1992

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TECHNICAL REPORT
BRITISH COLUMBIA
ENERGY SUPPLY AND REQUIREMENTS FORECAST
1978-1992

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FOREWORD

This is the British Columbia Energy Commission's 1978 review of the provincial energy supply and demand outlook. This forecast is done on a year to year basis from 1978 to 1982, and then at five year intervals to 1992.

The forecast of energy requirements contained in this report represents the Commission's view about future energy supplies and demands in British Columbia under specified assumptions. It does not purport to be a precise measure of what will happen in the future; nor is it a statement of government policy. The reader should recognize that any forecast requires numerous judgements to be made and that the accuracy of a forecast decreases the further into the future the forecast projects.

To illustrate possible variations in energy requirements over time, two requirements forecasts have been prepared, namely best estimate and high growth. Differences between the two forecasts are due largely to assumptions regarding conservation impacts and the timing and level of industrial activity. The best estimate forecast assumes greater savings from conservation in the commercial and transport sectors than occur under high growth, plus a slower rate of growth in industrial output in the period 1982-1987.

The report is made up of twelve chapters, plus appendices. A summary of British Columbia's energy outlook to 1992 is contained in Chapter 1. Chapter 2 is a summary of the major assumptions underlying the forecast, while Chapters 3 to 7 provide the detailed requirements forecasts by consuming sector: residential, commercial, industrial, transportation and other. In Chapter 8 the potential for coal as a substitute for other conventional forms of energy is analyzed, while Chapter 9 briefly reviews opportunities for non-conventional energy sources such as wind, biomass and solar.

The final chapters consist of a summary of total energy requirements (Chapter 10), forecasts of oil, natural gas, and electricity supply (Chapter 11), and an assessment of the extent to which the presently assured supply of these resources will be adequate to fulfill probable future requirements (Chapter 12).

Included in the appendices is a spearate study on requirements for selected refined petroleum products, including heavy fuel oil, gasoline, diesel fuel oil and light fuel oil.

All units of measure in this report are shown in the international system of units. Since most of the energy industry in Canada will have switched to the metric system within two years, a metric forecast seems appropriate. For those who wish to compare this forecast with previous forecasts, Table B1, containing conversion factors from Imperial units to metric units, has been included in Appendix B. As a rule of thumb, one quadrillion joules convert to approximately one trillion Btu's.

CHAPTER 1

BRITISH COLUMBIA'S ENERGY OUTLOOK
1978-1992

I. Introduction

The energy outlook for the next fifteen years in British Columbia is expected to be significantly different from the historical energy picture for a number of reasons:

- *Population growth and therefore, economic growth is expected to slow as a result of stricter immigration laws, lower birth rates and less interprovincial migration.*
- *As the Province's energy intensive resource industries mature, the growth in the economy can be expected to shift towards the less energy intensive sectors of secondary manufacturing and service industries.*
- *Higher energy prices and greater attention to conservation measures will act to limit demand.*

In combination, these changes are expected to lead to a considerable reduction in growth in demand for energy of all kinds.

The following sections contain a summary of the findings from the Commission's 1978 energy supply and requirements forecast.

II. Energy Outlook by Sector of End-Use

Residential Sector

1. Although population is forecast to increase at an average annual rate of 1.4 percent to 1992, household formation is expected to increase at 2.0 percent per annum. This phenomenum is attributable to increasing headship rates among the 15 to 35 year old age group and the "baby boom" generation moving into the household formation age bracket.

2. The introduction of the new residential building code by 1980 reduces per unit energy requirements for space heating in new buildings by 20 to 50 percent, depending on type of dwelling. Retrofitting of the existing housing stock and higher energy prices are both expected to decrease the rate of growth in energy requirements in the sector.

The impact of energy conservation throughout the residential sector is expected to reduce demand growth to just 1.2 percent per annum from 1977 to 1992--a rate below the rate of both population growth and household formation.

Commercial Sector

1. Historically the service industries have been increasing in importance in the Province's economy and this trend is expected to continue over the forecast period.

The education component of the commercial sector, however, is anticipated to diminish in importance as growth in the school age population decreases in the mid 1980's.

2. As in the residential sector, conservation measures, including a new commercial building code or guidelines, are expected to have a significant impact on future energy consumption. For example, conservation measures in educational institutions are anticipated to decrease energy consumption per square metre of floor space in new buildings by over 60 percent.

Two forecasts of energy requirements in the commercial sector have been prepared, assuming moderate and accelerated impacts of conservation. Annual growth rates are 2.4 percent for the base case, and 1.9 percent assuming accelerated conservation.

Industrial Sector

1. It is expected that secondary industry will increase in importance relative to the more energy-intensive primary industries. This shift will occur gradually, and will act to reduce rates of growth in energy consumption.

2. The forest industry, historically the largest industrial energy consumer in the province, will continue to be of primary importance to British Columbia's industrial base. Its importance, however, will decline relative to other types of industry as maximum utilization of the forest resource is approached. Both the mining and primary metals industries have significant potential for further growth.

It has not been possible to quantify the potential for energy savings through conservation in the industrial sector to the same degree as in the residential and commercial sectors. While some degree of conservation has been allowed for in this forecast, it is likely that the potential energy savings are higher than has been assumed.

3. Growth in consumption of energy by the industrial sector is forecast to average 3.0 percent per year to 1992, according to the best estimate forecast. A high growth forecast was also prepared. For this forecast, the average growth in energy requirements is about the same, but the growth is concentrated in the early years.

Transportation Sector

1. Energy requirements in the transportation sector are forecast to increase at an annual rate of between 2.7 percent and 1.8 percent under no-conservation and high conservation scenarios. Under the second scenario, in 1992 total fuel consumption by private passenger automobiles is forecast to be less than the 1978 level.

III. Energy Outlook by Fuel Type

Natural Gas

1. Under the best estimate forecast, the requirement for natural gas increases at an average rate of 2.2 percent per annum from 1977 to 1992. However, growth in natural gas demand is higher in the first five years of the forecast. The declining growth in natural gas demand is mainly a result of conservation efforts in the residential and commercial sectors and conversion to hog fuel in the forest industries.

Gas requirements under high growth and coal conversion scenarios were also forecast. The coal conversion scenario tested the impact on requirements of the widespread use of coal wherever technically and economically feasible.

Natural Gas Growth Rates
(Precentage/Year)

	1977-1982	1982-1992	1977-1992
Best Estimate	3.2	1.5	2.2
High Growth	3.5	1.9	2.4
Coal Conversion	2.9	.8	1.5

2. Natural gas supply will be more than adequate to fulfill domestic requirements during the forecast period, and depending on volumes delivered, should also be adequate to meet British Columbia's current export obligations under licence GL-41, net of gas supplied for this purpose from Alberta and the Yukon. Constraints may, however, be encountered from time to time in meeting both the maximum net export obligation of 226.5 quadrillion joules per year[1] and peak day requirements. The forecast supply/demand balance for natural gas, excluding the export market, is shown on an annual basis in Figure 1.1.

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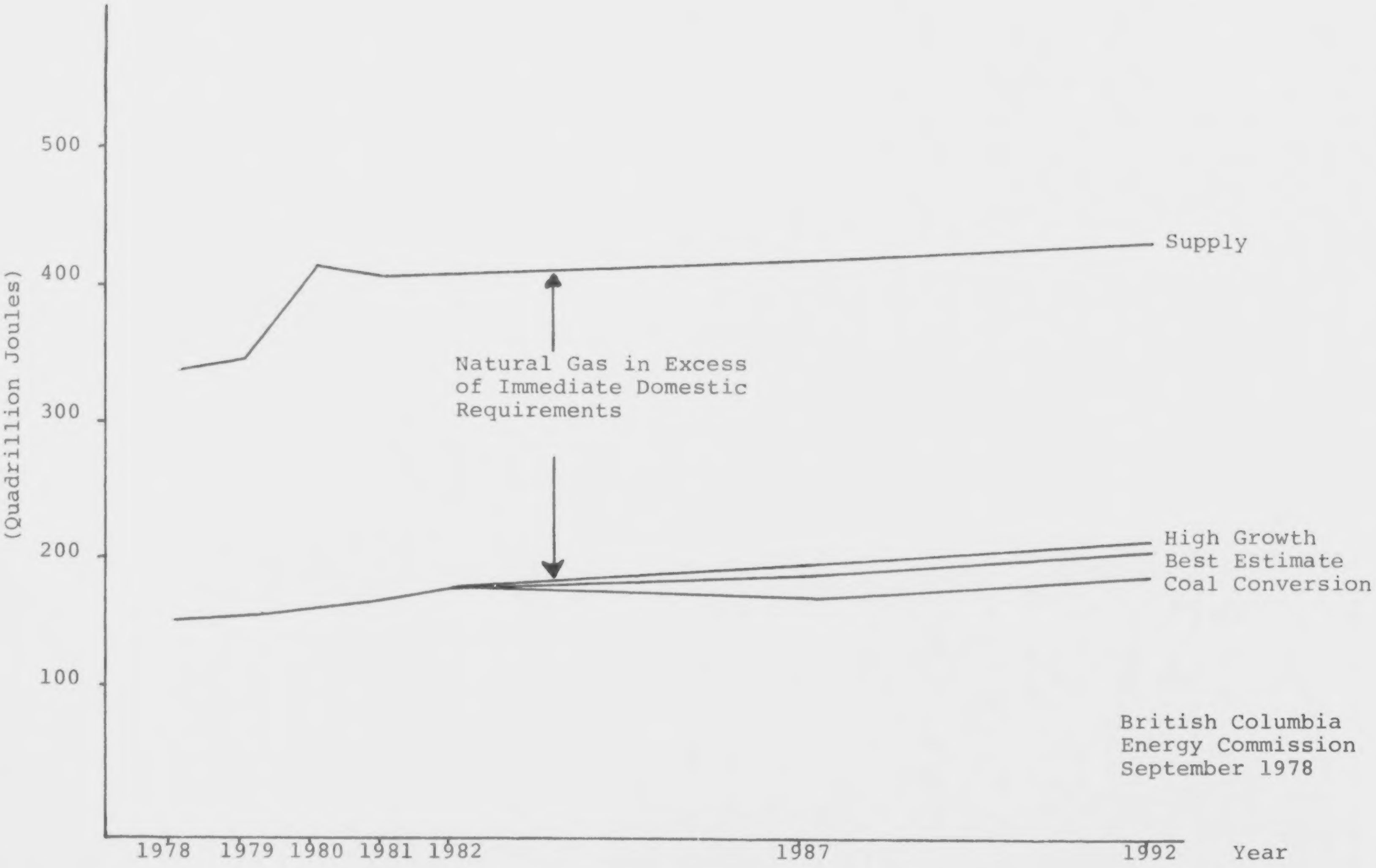
[1] *This export obligation is net of natural gas from Alberta and the Yukon exported under licence GL-41 at Huntingdon.*

FIGURE 1.1

NATURAL GAS SUPPLY DEMAND BALANCE



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Electricity

1. The share of total energy requirements supplied by purchased electricity is forecast to increase from 12.4 percent in 1977 to 14.0 percent in 1992. Growth in electricity demand is forecast to be between 3.3 percent and 3.7 percent per year under the best estimate and high growth forecasts respectively. The growth in electricity demand declines after 1982, mainly as a result of conservation measures and the declining growth in the province's population.

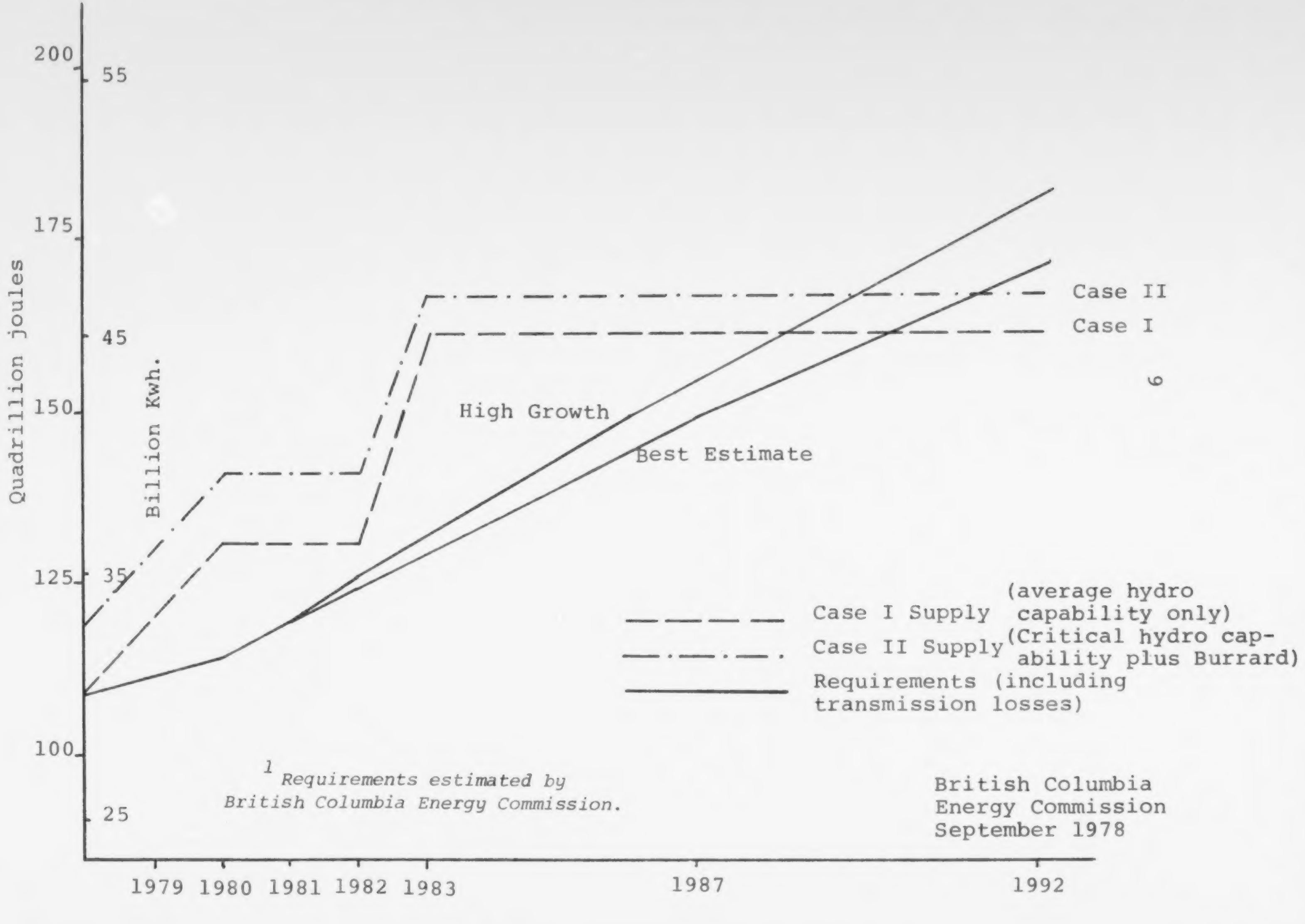
Electricity Growth Rates
(Percentage/Year)

	1977-1982	1982-1992	1977-1992
Best Estimate	3.7	3.1	3.3
High Growth	4.1	3.5	3.7
Coal Conversion	3.7	3.1	3.3

For the most part, increased demand for electricity will be met by the addition of generating facilities to B.C. Hydro's system. Figure 1.2 suggests that, based on existing and committed facilities, the B.C. Hydro system should have more than adequate capability to meet domestic requirements until at least 1988 under either Case I (average hydro-electric capability only) or Case II (critical hydro capability, plus Burrard thermal station at 70 percent utilization). Specific regional supply problems e.g. Vancouver Island have not, however, been evaluted.

FIGURE 1.2

B.C. HYDRO REQUIREMENTS AND SUPPLY[1]



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[1] *Requirements estimated by British Columbia Energy Commission.*

Refined Petroleum Products

1. Refined petroleum products' share of the total energy requirement falls over the forecast period from 43.5 percent to 38.4 percent. The growth in demand for petroleum products ranges from 1.6 percent to 2.2 percent per year under the coal conversion and high growth forecasts respectively.

Refined Petroleum Products
Growth Rates
(Percentage/Year)

	1977-1982	1982-1992	1977-1992
Best Estimate	2.0	1.5	1.6
High Growth	2.2	2.2	2.2
Coal Conversion	2.0	1.4	1.6

As with other fuels, the growth in demand for petroleum products declines after 1982. Figure 1.3 shows the supply/demand balance for liquid hydrocarbons (including liquified petroleum gases) in British Columbia until 1992.

The province is dependent on Alberta for approximately 75 percent of its crude oil requirement, and this dependancy is expected to increase. It is likely that sufficient supplies of oil from Alberta will be available to meet the slow increase in demand anticipated over the forecast period.[2]

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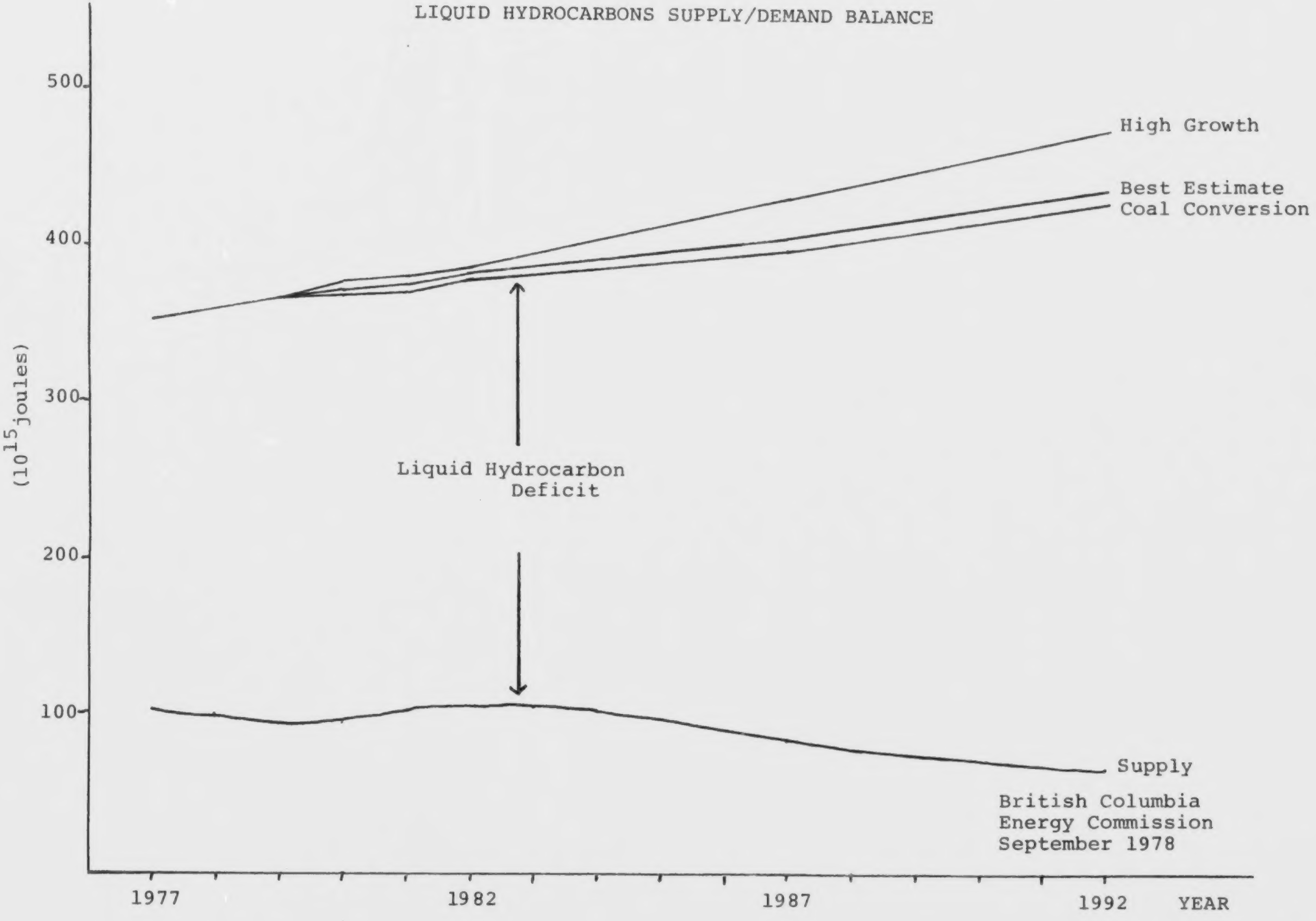
[2] *See National Energy Board Canadian Oil Supply and Requirements (September 1978) for additional discussion of Alberta producibility.*

FIGURE 1.3

LIQUID HYDROCARBONS SUPPLY/DEMAND BALANCE



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Other Fuels

1. Of the remaining fuels, coal and hog fuel experience the most rapid growth over the forecast period. British Columbia has an abundant supply of coal and it is expected that coal will be substituted for natural gas and oil as the latter become more expensive. The growth in coal demand is forecast to be between 10.1 percent and 15.2 percent over the forecast period, as shown below.

Coal Growth Rates
(Percentage/Year)

	1977-1982	1982-1992	1977-1992
Best Estimate	1.5	14.6	10.1
High Growth	1.5	14.6	10.1
Coal Conversion	9.4	18.3	15.2

2. Hog fuel and waste liquor consumption is also expected to experience relatively high growth as the forest industry introduces hog fuel boilers in their operations to displace the more expensive fuels (natural gas and oil) which they are currently burning. All new pulp mills are expected to operate almost entirely on fuels generated within the forest sector. The consumption of waste liquors as fuel

depends directly on the production of kraft pulp. Growth in the use of this fuel will therefore be the same as growth in kraft pulp production.

The table below indicates growth rates ranging from 3.0 percent in 1977-1982 to 3.7 percent in 1982-1992.

Hog Fuel/Waste Liquor Growth Rates
(Percentage/Year)

	1977-1982	1982-1992	1977-1992
Best Estimate	3.0	3.7	3.5
High Growth	3.0	3.7	3.5
Coal Conversion	3.0	3.7	3.5

CHAPTER 2

MAJOR ASSUMPTIONS

The major assumptions underlying this forecast are those concerning the future prices of energy resources; the future growth of the Province's population; and the future economic growth the province is likely to experience, both in extent and in type. These assumptions are discussed in some detail below.

Other important assumptions strongly influence particular sections of the forecast. In the transportation sector, for example, the forecast of motor vehicle gasoline consumption has been made in the full expectation that federal initiatives will be successful in increasing average motor vehicle fuel economy levels. The commercial and residential forecasts are based on the assumption that new building construction will be built using more energy-efficient building designs. Such sector specific assumptions are described in the detailed methodological descriptions that follow in Chapters 3 through 8.

Energy Prices

Assumptions about the probable future prices of all energy sources are an important part of any forecast of future energy requirements. Yet these types of assumptions are difficult to make with any degree of accuracy because energy prices are inter-related and influenced by a variety of factors which are themselves impossible to predict.

To illustrate, one goal of the federal government's energy policy has been to increase domestic oil prices towards parity with world oil prices, while at the same time moving natural gas prices towards parity with oil at the Toronto city-gate. Yet recently, the federal government has been willing to delay increases in the wellhead price for oil, and to suggest promotional prices for gas penetrating new markets in Quebec and possibly the Maritimes. Such shifts in policy can not be predicted beforehand with any degree of certainty.

These federal policies will affect oil prices in this province by virtue of the fact that British Columbia imports most of its oil from Alberta. Natural gas and electricity, however, are provincial resources and pricing policy for these fuels is largely at the discretion of the province.

Table 2.1 contains a comparision of average current fuel prices in Vancouver.[1] The prices for natural gas and electricity for 1977 were derived by dividing B.C. Hydro's total

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[1] *The average electricity and natural gas prices for 1978 were estimated by applying a percentage increase over 1977 average prices to reflect B.C. Hydro's recent rate increases.*

TABLE 2.1

FUEL PRICES IN VANCOUVER
(1977 Actual Average and 1978 Estimate)
(¢/GJ)

1977	Electricity	Natural Gas	Oil
Residential:	818.09	189.18[4]	303.98[6]
Commercial:	894.20[1] 583.91[2]	135.83[4]	301.70[7] 278.93[8]
Industrial:	276.68[3]	100.38[5]	n/a
1978			
Residential:	929.89	214.77[4]	324.47[6]
Commercial:	994.46[1] 685.23[2]	181.55[4]	322.20[7] 296.01[8]
Industrial:	316.67[3]	128.78[5]	162.05[9]

NOTES:
1. *General Service: under 35 kw*
2. *General Service: over 35 kw*
3. *Bulk Electricity Sales*
4. *Customers with natural gas space heating*
5. *Interruptible gas sales*
6. *Light fuel oil*
7. *Light fuel oil, no discount*
8. *Light fuel oil, with a discount*
9. *Heavy fuel oil, barge lots*

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revenue from sales in the different rate categories by the actual volumes of natural gas and electricity sold. Estimated prices for 1978 were obtained by applying B.C. Hydro's forecast average percentage increase in each category to the 1977 prices. Oil prices were taken from information received from the oil companies.

As can be seen from Table 2.1, average electricity prices in 1977 were four times higher than gas prices in the residential sector; up to six times higher in the general sales category; and almost three times higher in the large industrial sector. This difference is expected to narrow somewhat in 1978, especially in the commercial and industrial sectors where average prices of natural gas are estimated to increase more rapidly than electricity prices.

No attempt was made to forecast absolute levels of price changes from those shown in the Table. Rather, attention was focussed on relative future prices. Assumptions made in this respect will have a major impact on the way in which fuels share the energy market, and it is in this area where the largest forecasting error is likely to occur. This is because the sensitivity of fuel shares to relative fuel prices is much greater than the sensitivity of total energy consumption to the general level of energy prices.

It is expected that within the next ten years the following general trends are likely to emerge:

i) natural gas prices in all sectors will increase relative to oil prices, but will not exceed oil prices on a heat equivalent basis;

ii) electricity prices in all sectors will increase relative to oil prices, and, to a lesser extent, natural gas prices.

These two expectations, as well as the effects their realization would have on consumption, are discussed below.

Future Prices of Hydrocarbon Fuels

There is much doubt about the future course of world oil prices. Some observers suggest that OPEC oil prices will continue to climb as the oil cartel exercises its market power, while others believe that the cartel will break, and oil prices will fall, perhaps to $7.00/Bbl or less.

The Commission subscribes to the view that world oil prices will continue to increase, but at moderated rates, probably no greater than the general rate of inflation being experienced by western industrialized nations. Significantly higher rates are not likely because the world oil price is already at the limit where further increases would only serve to promote the drive for energy independence, hasten the search for new energy sources, and render economic those sources previously deemed uneconomic. Since these effects would only serve to erode the earnings potential of OPEC oil reserves, attempts by the cartel to increase oil prices too rapidly would not be in its own self-interest. In fact, the OPEC cartel has frozen oil prices in U.S. dollars for both 1977 and 1978.[2]

The world oil price influences oil prices in British Columbia only indirectly. Imports of crude oil and refined petroleum products from Alberta supply nearly 75 percent of British Columbia's needs. The price of oil produced in British Columbia is directly related to the Alberta oil price. To the extent that the Alberta crude price tracks the world price, this price will have a significant impact on the price of refined petroleum products in British Columbia. It is likely that within the next few years the prevailing price for oil products in this province will be at a level equal to, or perhaps marginally below, the world price.

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[2] *Notwithstanding OPEC pricing policies, the landed price of offshore crude has increased in recent months. One impact of the depreciation of the Canadian dollar relative to the United States and other currencies has been to increase to Canada the world price of oil, which is set in U.S. dollars.*

With respect to natural gas, British Columbia is fortunate in that it can look forward to self-sufficiency for some time to come. Investment opportunities available to natural gas producers in Alberta, and in frontier areas, will compete with those available in British Columbia, and therefore do influence the wellhead price in this province. In large measure, however, the province will be in a position to exert control over its field and wholesale prices for natural gas.

It is probable that while natural gas prices will increase over time relative to oil, these prices will remain below parity with oil prices on a heat equivalent basis in most markets. This assumption is sufficient for forecasting purposes in the residential and commercial sectors, since natural gas will normally be preferred to oil at any price below heat equivalent price.

Future prices in the industrial sector and their impacts are more difficult to assess. Natural gas is normally sold to industry either on a firm or interruptible basis.[3] Hence, a customer's preference for natural gas or oil will be conditioned by a number of factors: the price of oil relative to both firm and interruptible gas, the use to which the fuel is being put, the likelihood of interruption, and the extent to which the customer is willing to accept interruption. It is not possible to typify the industrial market by defining an average customer, or to project fuel shares in the industrial sector by forecasting the reactions of an average customer to relative price changes.

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[3] *An "interruptible" customer is one to whom service may be interrupted in order to fulfill the requirements of "firm" customers.*

Further complicating the industrial picture is the fact that the heavy fuel oil normally consumed by industry is not, from the point of view of a refinery, a premium product. Hence, production of heavy oil is not generally geared to demand, as is the production of gasoline or aviation fuel. In times of over-supply, refiners will often offer heavy oil to customers at distress prices in order to sell it. This volatility which characterizes heavy fuel oil prices makes its consumption extremely difficult to forecast, especially for those segments of the industrial market that are equipped with dual-firing equipment.

In the forecast which follows, it is assumed that industry's preference for natural gas will continue to prevail. It is recognized, however, that an increasing relative price of gas will, in at least some cases, result in an increased consumption of heavy fuel oil. This would be particularly true for those interruptible customers who already have dual-burning facilities in place to allow them to switch between oil and natural gas in response to market prices.

Currently, a surplus of heavy fuel oil exists on the United States west coast, allowing industrial customers access to a low cost energy supply source. In the short term, these supply conditions will constrain conversion to either natural gas or, in the forest products industry, to hog fuel.

Future Electricity Prices

Prices for electricity are expected to rise relative to oil and natural gas prices in this province over the forecast period, for a number of reasons.

Unit costs of electrical capacity are increasing as progressively more expensive generation sites are utilized. This is to be expected, for the lowest cost resources are generally the first to be exploited. It is unlikely that this trend will cease, and therefore the real cost of an extra megawatt of capacity will probably rise continuously.

Coincident with increasing unit capacity costs are likely to be increasing unit transmission costs as hydro sites now being considered are generally more remote from the centres of electrical consumption.

At present, electricity prices are set on the basis of historic costs. As new generation facilities are brought on stream, these higher costs will ultimately be reflected in the rate base and in the rates charged by B.C. Hydro and other utilities.

Major increases in rates above these levels could occur, however, if, similar to oil and natural gas prices, rates were set in the market place to reflect more closely current replacement cost. For instance, home heating fuel in Vancouver already costs about 80 percent of what it would cost using imported oil at world prices; and natural gas is priced at levels close to finding costs for new gas in the province.

New electrical generation facilities that are currently under construction, such as Revelstoke, or ones tentatively planned for the future, such as Hat Creek, will produce electricity at a cost considerably higher than the current historical average. If the electrical utilities adjust their domestic rate schedule to reflect these higher production costs, then the price of electricity to domestic consumers will increase substantially over current prices. Such a pricing policy, however, would represent a fundamental shift in pricing for the industry.

Although the price of electricity is expected to increase relative to oil and natural gas, the actual magnitude of this relative increase is extremely uncertain. The increase in electricity prices will be greatly affected by the extent to which new generating capacity is required and by whether B.C. Hydro is able to export surplus electricity at a sufficiently high price to reduce the upward pressure on domestic prices. The potential impact of either of these factors is not known.

The need for new capacity is directly related to growth in electricity demand, which in turn is greatly affected by the price of electricity. Even under the assumption of increasing relative price of electricity, growth in electricity demand is still expected to be significantly higher than growth in total energy demand. This is primarily a result of the attractiveness of electricity in many existing and new applications, and its necessity in others.

The above discussion summarizes the relative price assumptions that have been used for the various fuels in the forecast which follows. It will be noted that nowhere have elasticity coefficients been used to forecast either levels of consumption or fuel shares. The reasons are, in the first place, that such coefficients are difficult to measure with any degree of theoretical accuracy (although statistical accuracy may be achieved); and, in the second place, even if theoretical accuracy were achievable, the validity of using coefficients estimated on the basis of historical price data to project future consumption levels and fuel shares is doubtful.

Population

The population forecast presented here is an integral part of the energy demand forecast for each of the sectors in the province. The forecast has been done on a regional basis such that regional boundaries are coincident with census division or sub-division boundaries. These regions are also defined on the basis that except for Omineca-Peace, no region is served by more than one gas utility. Figure 2.1 illustrates this regional split and Table 2.2 contains the definition of each of the seven regions by census divisions and sub-divisions.

A cohort simulation model was used for the purpose of forecasting population. This model involves taking a base population by five year age cohorts and applying age and sex specific fertility, mortality and migration rates to these cohorts.

FIGURE 2.1

BRITISH COLUMBIA REGIONAL BOUNDARIES

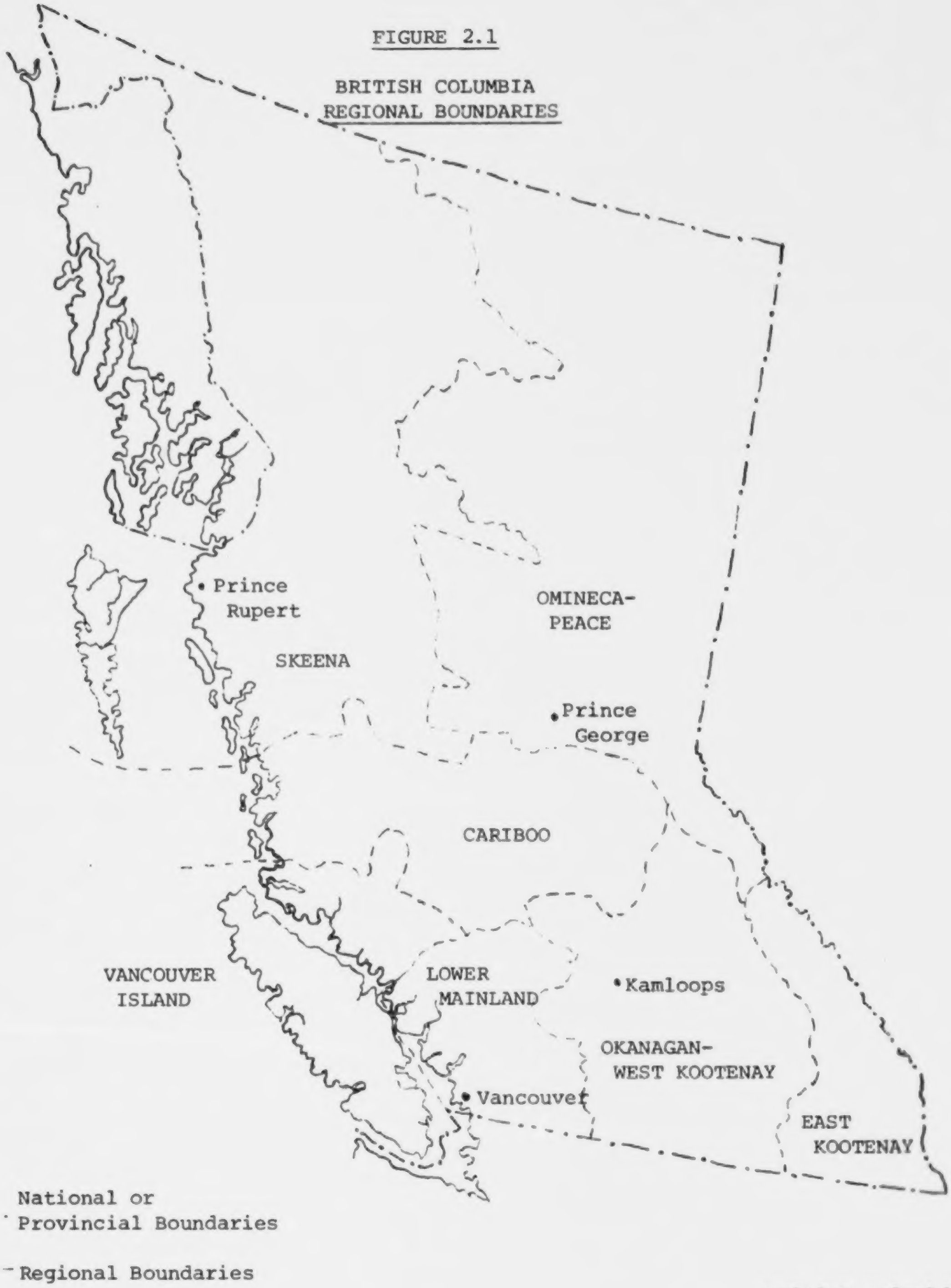
Prince Rupert
SKEENA
OMINECA-PEACE
Prince George
CARIBOO
VANCOUVER ISLAND
LOWER MAINLAND
Kamloops
OKANAGAN-WEST KOOTENAY
Vancouver
EAST KOOTENAY
National or Provincial Boundaries
Regional Boundaries

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TABLE 2.2

DEFINITION OF REGIONS

Region Name	Census Division
Skeena	Bulkley-Nechako Kitimat-Stikine Skeena-Queen Charlotte Stikine
Omineca-Peace	Fraser-Fort George Peace River-Liard
Cariboo	Cariboo Central Coast
Okanagan-W. Kootenay	Central Kootenay (Subdivisions "A" & "B") Central Okanagan Columbia-Shuswap (Subdivision "B" & "C") Kootenay Boundary North Okanagan Okanagan Similkameen Thompson-Nicola
East Kootenay	Central Kootenay (Subdivision "C") Columbia-Shuswap (Subdivision "A") East Kootenay
Lower Mainland	Central Fraser Valley Dewdney-Allouette Fraser-Cheam Greater Vancouver Powell River Squamish-Lillooet Sunshine Coast
Vancouver Island	Alberni-Clayoquot Capital Comox-Strathcona Cowichan Valley Mount Waddington Nanaimo

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The population data base underlying the forecast was obtained from the Statistics Canada 1976 census. Fertility, mortality and migration rates have been forecast independently.

Age specific fertility rates were obtained by adjusting the rates underlying Statistics Canada's Population Projections for Canada and the Provinces, 1972-2001, Catalogue 91-514, to reflect the changes in fertility distribution between age groups and the slight lowering of overall fertility rates as now projected by Statistics Canada.

The age and sex specific mortality projections used in the forecast were also taken from the same report. National rates are used for British Columbia as it appears that the difference between national and provincial mortality rates is minimal. Statistics Canada gives a mortality rate projection for the time period 1985 to 1989. Mortality rates before this time are calculated by extrapolating on a straight line basis from actuals given for 1965 to 1969.

For the purposes of this forecast, migration has been divided into its international and interprovincial components. Unfortunately, insufficient data on inter-regional population flows within the province makes it impossible to define the future effects of this component of migration on the regional distribution of the population.

Net international migration is the difference between immigration and emigration. In recent years the volume of both of these components has been declining. According to the Canadian Employment and Immigration Commission, the number of immigrants coming into Canada, with British Columbia as their stated destination, has fallen from 29,272 in 1975 to 20,484 in 1976 to approximately 16,000 in 1977. New federal immigration policy changes which link immigration to Canada's labour and population needs are likely to further reduce these numbers. Therefore, it has been assumed that immigration rates will fluctuate around the 15,000 per year mark for the forecast period. Emigration rates, which have been falling since 1961, are assumed to stay at the 1975-1976 low value of 4,000 per year over the forecast period. This results in a net international migration gain of 11,000 persons per year.

Interprovincial migration is the most volatile factor affecting population growth in British Columbia. Opportunities for employment both in and out of the province can rapidly change this component of migration as the following historical series shows:

Year	Net Annual Interprovincial Migration
1972-73	27,333
1973-74	30,496
1974-75	11,831
1975-76	- 4,419
1976-77	- 1,466

The 1976 Review and Outlook report on British Columbia economic activity, published by the provincial Ministry of Economic Development, forecasts that employment growth rates will increase in the short term as recovery in export markets continues and the resulting multiplier impacts are transmitted to the non-export sectors of the economy. Specific projects such as the B.C. Hydro generation plant at Revelstoke and the Foothills natural gas pipeline will also provide stimulus to employment growth, especially in the years 1979 through 1982. Taking these factors into account, interprovincial migration rates have been forecast as follows:

Year	Projected Net Annual Interprovincial Migration
1977	6,000
1978	8,000
1979	10,000
1980	12,000
1981	14,000
1982+	14,000

The distribution of both net international and net interprovincial migrants by age and sex are assumed to be the same as that reported in the 1971 census.

Table 2.3 gives a regional summary of the population forecast to 1992. This forecast translates to an average annual compound growth rate of 1.3 percent for 1977 to 1982, 1.4 percent for 1982 to 1987, and 1.3 percent from 1987 to 1992.[4]

Economic Growth

The Gross Provincial Product Forecast

Table 2.4 contains estimates of British Columbia's Gross Provincial Product and population produced by the Ministry of Economic Development for the years 1965 to 1976. The Gross Provincial Product figures have been converted to 1976 constant dollar terms by applying Gross National Expenditure (GNE) adjustment factors. Dividing the real Gross Provincial Product figures by provincial population yields a real per capita Gross Provincial Product series for the years 1965 to 1978.

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[4] *This population forecast compares closely with unpublished estimates prepared by Statistics Canada in updating their original 1972-2001 projections. Projection 3 of this new series, for example, estimates a 1992 population of 3.11 million, based on net migration levels similar to those employed in this report.*

TABLE 2.3

POPULATION FORECAST REGIONAL SUMMARY

Region	Actual 1976	1977	1978	1979	1980	1981	1982	1987	1992
Vancouver Island	441,400	444,761	448,705	453,232	458,342	464,037	470,314	501,816	533,791
Lower Mainland	1,324,905	1,338,211	1,352,806	1,368,688	1,386,857	1,404,316	1,242,058	1,522,283	1,618,548
Okanagan West Kootenay	361,048	364,332	368,107	372,373	377,130	382,380	388,120	417,007	446,640
East Kootenay	63,238	63,875	64,790	65,683	66,654	67,705	68,834	74,516	80,332
Cariboo	55,810	56,665	57,589	58,582	59,644	60,774	61,975	68,017	74,198
Omineca - Peace	124,430	126,519	128,761	131,156	133,704	136,407	139,261	153,618	168,313
Skeena	95,510	97,013	98,636	100,379	102,242	104,228	106,330	116,930	127,698
Total B.C.	2,466,341	2,491,476	2,519,394	2,550,093	2,583,573	2,619,847	2,658,892	2,854,187	3,049,698

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TABLE 2.4

BRITISH COLUMBIA HISTORICAL POPULATION AND REAL GROSS PROVINCIAL PRODUCT

	Real GPP[1] (1976$ x 10^6)	Population (000)	Real GPP/capita (1976$)
1965	11,569	1797	6438.0
1966	12,506	1874	6673.3
1967	13,062	1945	6715.8
1968	13,831	2003	6905.0
1969	14,989	2060	7276.0
1970	15,330	2128	7204.0
1971	16,658	2185	7623.7
1972	17,843	2247	7940.8
1973	19,782	2315	8545.1
1974	20,460	2395	8542.8
1975	20,649	2457	8404.2
1976	21,304	2466	8637.5
11 year average compound growth	5.7%	2.9%	2.7%

SOURCE: Ministry of Economic Development, British Columbia Economic Activity, 1977 Review and Outlook, March, 1978.

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[1] *Current dollar figures were converted to 1976 constant dollar figures by using the GNE adjustment factor.*

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In order to forecast GPP, the per capita series was simply regressed linearly on time. A good fit was obtained[5] and the variable was projected through to 1992. This per capita coefficient was then multiplied by the population forecast to yield a forecast of Gross Provincial Product. The results are shown in Table 2.5.

According to this forecast, growth in GPP will be an average of 3.5 percent per year over the forecast period. Growth in GPP reaches a peak in 1981 at 3.6 percent and levels off thereafter to 3.2 percent per year for the remainder of the forecast period. Growth in real GPP per capita is forecast to average 2.1 percent per year, as compared to the eleven year historical annual average of 2.7 percent.

The slower growth forecast for real GPP of 3.5 percent as compared with previous forecasts of around 4.5 percent is largely a result of the slower growth expected in the province's population. It has also been recognized that the rapid growth experienced in the 50's and 60's is not a long run phenomenum to be used in predicting the future trend of the economy. In a recent report,[6] the Hudson Institute of Canada suggested that

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[5] *The regression equation used here was :* $RGPP/P = (209.316)t + 6174.685$ $R^2 = .977$.

[6] *Globe and Mail, Report on Business, Friday, May 26, 1978.*

TABLE 2.5

FORECAST OF REAL GROSS PROVINCIAL PRODUCT

	RGPP/P	Population (000)	RGPP (1976$ x 10^6)
1977	8895.8	2491.5	22,163.9
1978	9105.1	2519.4	22,939.4
1979	9314.4	2550.1	23,752.7
1980	9523.7	2583.6	24,605.4
1981	9733.1	2619.8	25,498.8
1982	9942.4	2658.9	26,435.8
1987	10989.0	2854.2	31,364.8
1992	12035.5	3049.7	36,704.8
average compound growth	2.04%	1.36%	3.43%

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the long run stable growth in real GNP for Canada is between 2 and 2.5 percent per year, reflecting increased business costs and risks and increased social costs and more regulation. Their shorter term outlook for real GNP was growth rates in the neighbourhood of 3.5 to 4.0 percent per annum up to 1982.

CHAPTER 3

RESIDENTIAL SECTOR ENERGY REQUIREMENTS

I. Forecast Methodology

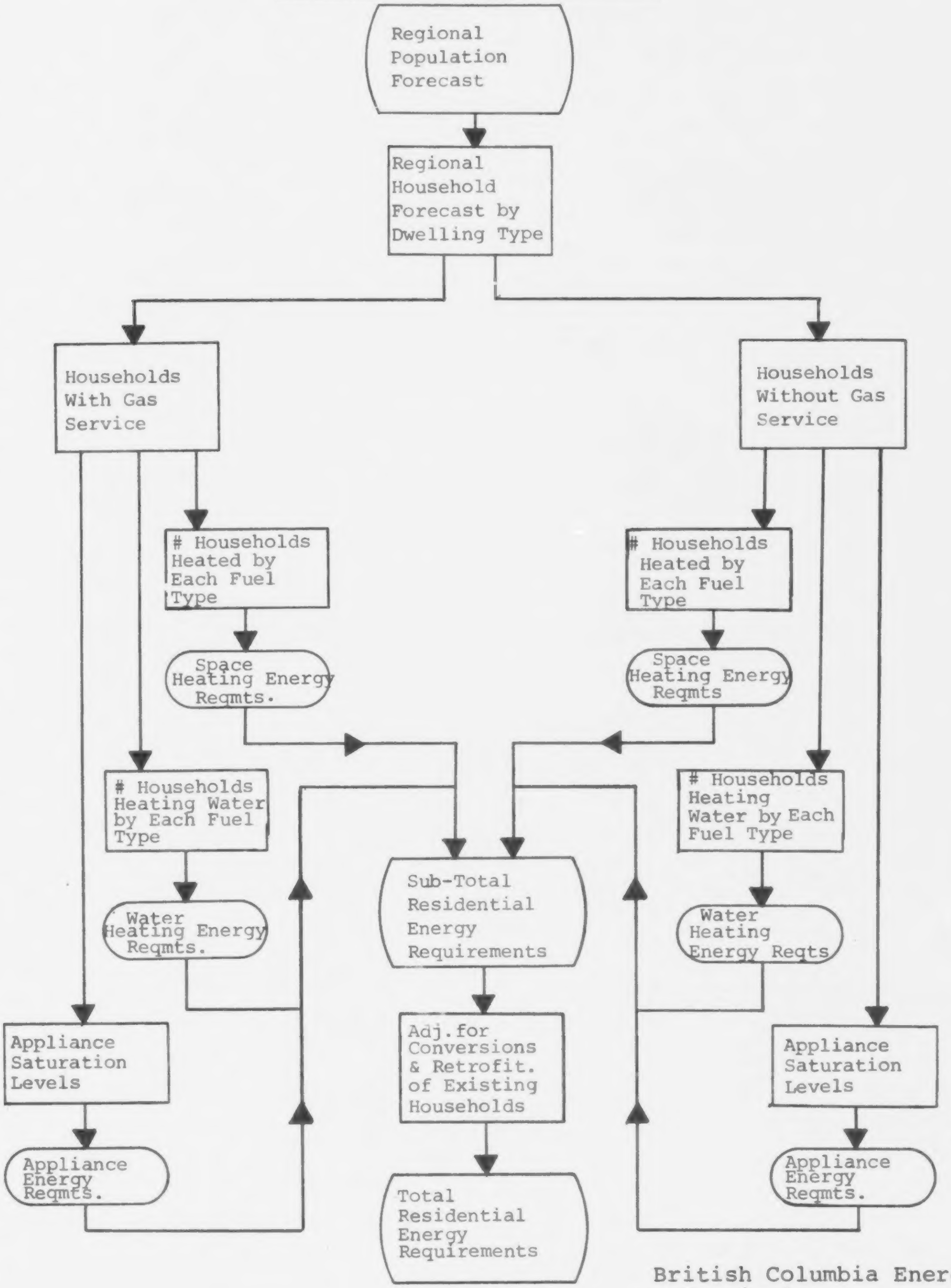
The residential sector consists of all private dwellings in the province, including single detached and attached houses, apartments and mobile homes. Energy consumption in this sector derives principally from requirements for space heating, water heating, lighting and appliance use.

The forecast of residential energy requirements has been undertaken on a regional basis. This approach has been employed in order to account for large regional disparities in gas service availability and in climatic conditions. The forecast was made by adding forecast incremental energy requirements to an actual base year consumption level. To do this, forecasts of population and households by dwelling type were made. Both the amount and type of energy to be used by housing stock additions were then calculated and added to base consumption. Finally, an adjustment was made to base year energy use in order to account for conservation through retrofitting and changed patterns of energy use. Figure 3.1 gives a schematic diagram of the forecast methodology.

FIGURE 3.1

FLOW CHART

RESIDENTIAL ENERGY FORECAST


Regional Population Forecast
Regional Household Forecast by Dwelling Type
Households With Gas Service
Households Without Gas Service
# Households Heated by Each Fuel Type
Space Heating Energy Reqmts.
# Households Heated by Each Fuel Type
Space Heating Energy Reqmts
# Households Heating Water by Each Fuel Type
Water Heating Energy Reqmts.
Sub-Total Residential Energy Requirements
# Households Heating Water by Each Fuel Type
Water Heating Energy Reqts
Appliance Saturation Levels
Adj. for Conversions & Retrofit. of Existing Households
Appliance Saturation Levels
Appliance Energy Reqmts.
Total Residential Energy Requirements
Appliance Energy Reqmts.

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Although regional estimates of energy consumption are not currently available for the commercial, industrial or transport sectors, the Commission hopes to be able to publish such estimates at a future date.

II. Base Year Energy Consumption

By virtue of the regional nature of the forecast, it was necessary to obtain base year (1976) consumption levels by region. The methods used to derive regional estimates, as well as the estimates themselves, are contained in the following sections.

Electricity

Electricity consumption figures for the residential sector were, for the most part, taken from B.C. Hydro records of 1976 electricity sales. Because these records are broken down into sales to each sector in each power district, they can be tabulated to conform to the seven consuming regions adopted in this report. The only major area not served by B.C. Hydro falls almost totally within the Okanagan-West Kootenay region (with the exception of Creston). Part of this region is served by West Kootenay Power and Light and the six small utilities to which it supplies electricity on a wholesale basis. Finally, the town of Lower Post is served by Yukon Electric.

The residential consumption of electricity, by region, in 1976 was as follows:

	GWH	Quadrillion Joules (10^{15})
Vancouver Island	1,609	5.794
Lower Mainland	3,339	12.019
Okanagan-West Kootenay	1,349	4.855
East Kootenay	186	.669
Cariboo	183	.658
Omineca-Peace	377	1.357
Skeena	342	1.232
Total B.C.	7,385	26.584

Natural Gas

There are currently seven natural gas utilities serving British Columbia.[1] Six of these utilities service only one region. Residential consumption figures reported by each of these were therefore readily allocated to the appropriate regions. Inland Natural Gas, the seventh utility, serves three regions--Okanagan-West Kootenay, Cariboo, and Omineca-Peace. This utility reports consumption by communities, making it possible to define residential gas use by region.

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[1] *B.C. Hydro, Inland, Pacific Northern, Columbia, Northland, Plains-Western and Fort Nelson Natural Gas.*

None of these residential consumption figures include apartment use as apartments are billed at a commercial rate. Therefore, separate estimates of natural gas consumption were made for this type of dwelling. While 1976 census data provided the total number of apartments in each region, statistics from Household Facilities and Equipment [2] gave the proportion of apartments using natural gas. It has been assumed that the percentage of apartments using natural gas is the same in each gas-serviced region in British Columbia. From the above information, estimates of the total number of apartments using natural gas in each region were made. By multiplying these estimates by use per apartment figures ranging from 0.823 quadrillion joules per annum for the Lower Mainland to 0.928 quadrillion joules per annum for the Omineca-Peace region, regional estimates of apartment consumption were made.[3]

Estimates of 1976 natural gas consumption in the residential sector (including apartment consumption) are as follows:

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[2] *Household Facilities and Equipment*, *Statistics Canada, Catalogue 64-202.*

[3] *B.C.E.C. estimate.*

	Quadrillion Joules (10^{15})
Vancouver Island	-
Lower Mainland	37·098
Okanagan-West Kootenay	6·330
East Kootenay	1·418
Cariboo	·433
Omineca-Peace	3·300
Skeena	·563
Total B.C.	49·142

Refined Petroleum Products and L.P.G.'s

Residential sector consumption of refined petroleum products involves the use of kerosene, stove oil, light fuel oil and heavy fuel oil. Total British Columbia residential consumption of these products in 1976 was obtained from Statistics Canada.[4] Since domestic use of liquified petroleum gases (L.P.G.'s) has changed very little over the past few years and since 1976 data was not available, 95 percent of 1975 residential and farm consumption of L.P.G.'s, as reported in Statistics Canada's publication Detailed Energy Supply and Demand (Catalogue 57-207) was used as an estimate of 1976 residential consumption. The remaining 5 percent was arbitrarily estimated to have been used for commercial purposes in the farming sector.

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[4] *Refined Petroleum Products: Consumption of Petroleum Products*, *Statistics Canada, Catalogue 45-208.*

In order to disaggregate these total provincial consumption figures on a regional basis, estimates of total regional output heat requirements were made by the Energy Commission. This was done by applying to the number of single detached, single attached, apartment and mobile units in each region an estimate of their respective requirements. From each estimated regional requirement, the known portion of the requirement supplied by natural gas and electricity was subtracted. The distribution of the resulting residuals (to be supplied by oil and L.P.G.'s) was then applied to the known provincial oil and L.P.G. consumption. The resulting estimates for 1976 residential consumption are as follows:

	Quadrillion Joules	
	R.P.P.	L.P.G.'s
Vancouver Island	12.652	2.384
Lower Mainland	9.219	1.738
Okanagan-West Kootenay	6.113	1.152
East Kootenay	.687	.129
Cariboo	1.176	.222
Omineca-Peace	1.079	.204
Skeena	1.765	.332
Total B.C.	32.691	6.161

Total Energy

Table 3.1 summarizes total and fuel specific estimates of base year (1976) energy consumption in the residential sector. Fuel shares of residential consumption are also shown.

III. Households Forecast

Four dwelling types are considered in this forecast; single detached, single attached (row houses, duplexes etc.), apartments and mobile homes. The number of each type of household is largely dependent on the age composition of the population. In general, household heads move from apartment type dwellings to larger single detached dwellings during the family formation stage, then back to smaller dwellings after the family has left home. Since the age distribution of British Columbia's population is rapidly changing, a household forecast based on the distribution of household heads in each age group by dwelling type was adopted.

To prepare the household forecast, the population over 15 years of age was first split into six age groups. Using Statistics Canada 1971 and 1976 census information detailing types of dwellings occupied in British Columbia by age of household head, a forecast of coefficients for each age group by housing type was made. This forecast of headship

TABLE 3.1

RESIDENTIAL CONSUMPTION OF ENERGY, BY REGION, 1976
(Quadrillion joules)

	Electricity	Natural Gas	R.P.P.	L.P.G.	Total
Vancouver Island	5.794	-	12.652	2.384	20.830
Percent	(27.8)		(60.7)	(11.5)	(100.0)
Lower Mainland	12.019	37.098	9.219	1.738	60.074
Percent	(20.0)	(61.7)	(15.3)	(3.0)	(100.0)
Okanagan-West Kootenay	4.355	6.330	6.113	1.152	18.450
Percent	(26.3)	(34.3)	(33.1)	(6.3)	(100.0)
East Kootenay	.669	1.418	.687	.129	2.903
Percent	(23.0)	(48.8)	(23.7)	(4.5)	(100.0)
Cariboo	.658	.433	1.176	.222	2.489
Percent	(26.4)	(17.4)	(47.2)	(9.0)	(100.0)
Omineca-Peace	1.357	3.300	1.079	.204	5.940
Percent	(22.8)	(55.6)	(18.2)	(3.4)	(100.0)
Skeena	1.232	.563	1.765	.332	3.892
Percent	(31.7)	(14.5)	(45.3)	(8.5)	(100.0)
Total B.C.	26.584	49.142	32.691	6.161	114.578
Percent	(23.2)	(42.9)	(28.5)	(5.4)	(100.0)

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rates was based on the assumption that overall headship rates will increase, as has been the case in the past (see Figure 3.2).

Increases in headship rates are assumed to be due to factors such as younger household heads and increased divorce rates, which will generally result in a higher rate of non-family household formation. Therefore, it has been assumed that increased headship rates to 1981 will affect only the demand for apartments and single attached homes (row houses, duplexes etc.). Headship rates for these two dwelling types are each assumed to increase to 1981 at their combined growth rate for the period 1971 to 1976. Headship rates for all age groups and housing types are held constant after 1981.

Table 3.2 shows 1971, 1976, and forecast total age-specific headship rates. These coefficients were multiplied by forecasted age-specific population cohorts to give growth rates for total future households by dwelling type. This method of calculating household additions results in average persons per household rates of 2.93 in 1977, 2.75 in 1982, 2.70 in 1987 and 2.65 in 1992. In comparison, the 1976 census estimate is 2.98 persons per houehold. The slower rate of decline in persons per household in later years can be traced to changes in population distribution and constant headship rates after 1981.

FIGURE 3.2

TOTAL AGE SPECIFIC HEADSHIP RATES

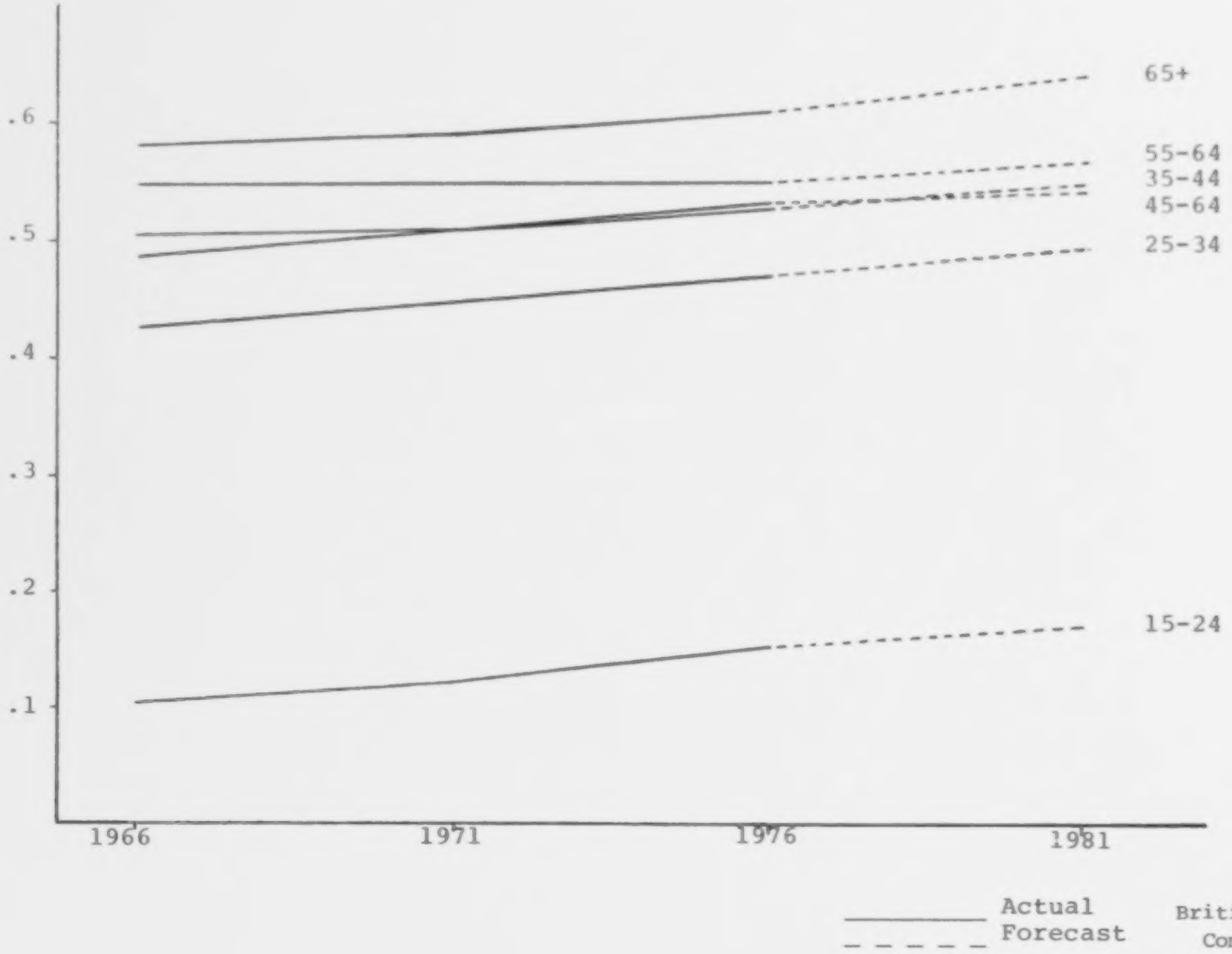

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TABLE 3.2

TOTAL AGE SPECIFIC HEADSHIP RATES*

Age	1971 (Actual)	1976 (Actual)	1981 (Forecast)
15-24	.1252	.1555	.1791
25-34	.4562	.4795	.4956
35-44	.5158	.5334	.5540
45-54	.5155	.5373	.5527
55-64	.5540	.5570	.5714
65+	.5948	.6103	.6451

* Figures represent proportion of each age group heading a household.

Table 3.3 details the housing type specific forecast, while Table 3.4 gives regional household totals.

IV. Energy Requirements Forecast

At this stage of the forecast, the base year (1976) consumption figures for each fuel in each region are known, and a regional forecast of the stocks of four different dwelling types has been made. It remains only to forecast the energy requirements for each region's incremental housing stock, and to estimate the contribution that each fuel will make to the fulfillment of those requirements.

As a first step, estimates are made of the number of new units that will opt for each of the alternative fuels to fulfill their energy requirements for space heating, water heating, and appliances. Then incremental output energy requirements are calculated for each of these end-uses. Finally, the incremental input energy requirement is found by applying an appropriate conversion factor (the efficiency of the selected fuel) to the output energy requirement.

Capture Rates and Gas Service Factors

The rates at which different fuels will capture new residential energy loads are forecast separately for areas which have natural gas service and for those which do not. Natural gas requirements are for the British Columbia mainland only, and no estimate has been made of possible additional gas requirements should service be extented to Vancouver Island.

TABLE 3.3

REGIONAL HOUSEHOLD FORECAST
BY DWELLING TYPE

REGION	DWELLING	ACTUAL 1976	1977	1978	1979	1980	1981	1982	1987	1992
Vancouver Island	Sing. Det.	99,550	101,541	103,572	105,643	107,756	109,911	112,252	124,422	136,566
	Sing. Att.	12,710	13,274	13,864	14,479	15,122	15,794	16,066	17,429	18,619
	Apartment	32,785	34,126	35,522	36,974	38,487	40,061	40,614	43,426	46,140
	Mobile	8,900	9,042	9,187	9,334	9,483	9,635	9,779	10,503	11,148
Lower Mainland	Sing. Det.	270,095	275,497	281,007	286,627	292,360	298,207	304,559	337,578	370,526
	Sing. Att.	38,685	40,403	42,196	44,070	46,027	48,070	48,897	53,045	56,668
	Apartment	140,885	146,647	152,645	158,888	165,387	172,151	174,527	186,611	198,275
	Mobile	8,330	8,463	8,599	8,736	8,876	9,018	9,153	9,832	10,436
Okanagan W. Kootenay	Sing. Det.	81,997	83,637	85,310	87,016	88,756	90,531	92,459	102,483	112,485
	Sing. Att.	11,218	11,716	12,236	12,780	13,347	13,940	14,180	15,383	16,436
	Apartment	12,799	13,322	13,867	14,435	15,025	15,639	15,855	16,953	18,012
	Mobile	12,040	12,269	12,502	12,739	12,981	13,228	13,479	14,766	15,986
East Kootenay	Sing. Det.	13,613	13,885	14,163	14,446	14,735	15,030	15,350	17,014	18,675
	Sing. Att.	1,392	1,454	1,518	1,586	1,656	1,730	1,759	1,909	2,039
	Apartment	1,951	2,031	2,114	2,200	2,290	2,384	2,417	2,584	2,746
	Mobile	3,145	3,220	3,298	3,377	3,458	3,541	3,619	4,023	4,420
Cariboo	Sing. Det.	10,905	11,123	11,346	11,572	11,804	12,040	12,296	13,629	14,959
	Sing. Att.	1,265	1,321	1,380	1,441	1,505	1,572	1,599	1,735	1,853
	Apartment	1,320	1,374	1,430	1,489	1,550	1,613	1,635	1,748	1,857
	Mobile	2,650	2,729	2,811	2,896	2,983	3,072	3,158	3,615	4,090
Omineca-Peace	Sing. Det.	24,040	24,521	25,011	25,511	26,022	26,542	27,107	30,046	32,979
	Sing. Att.	3,790	3,958	4,134	4,318	4,509	4,709	4,790	5,196	5,551
	Apartment	3,535	3,680	3,830	3,987	4,150	4,320	4,380	4,683	4,976
	Mobile	4,475	4,623	4,775	4,933	5,096	5,262	5,416	6,230	7,083
Skeena	Sing. Det.	16,285	16,611	16,943	17,282	17,627	17,980	18,363	20,354	22,341
	Sing. Att.	3,685	3,847	4,019	4,198	4,384	4,579	4,658	5,053	5,398
	Apartment	2,705	2,816	2,931	3,051	3,175	3,305	3,351	3,583	3,807
	Mobile	3,555	3,672	3,794	3,919	4,048	4,182	4,303	4,950	5,628

TABLE 3.4

REGIONAL HOUSEHOLD FORECAST

All Dwelling Types

REGION	ACTUAL 1976	1977	1978	1979	1980	1981	1982	1987	1992
Vancouver Is.	153,945	157,983	162,145	166,430	170,848	175,401	178,711	195,780	212,473
Lower Mainland	457,995	471,010	484,447	498,321	512,650	527,446	537,136	587,066	635,905
Okanagan-W. Kootenay	118,054	120,944	123,915	126,970	130,109	133,338	135,973	149,585	162,919
East Kootenay	20,101	20,590	21,093	21,609	22,139	22,685	23,145	25,530	27,880
Cariboo	16,140	16,547	16,967	17,398	17,842	18,297	18,688	20,727	22,759
Omenica-Peace	35,840	36,782	37,750	38,749	30,777	40,833	41,693	46,354	50,589
Skeena	26,230	26,946	27,687	28,450	29,234	30,046	30,675	33,940	37,174
Total	828,305	850,802	874,004	897,927	922,599	948,046	966,021	1,058,982	1,149,699

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Additions to dwelling stocks of each type and in each region were disaggregated into those which are expected to have access to gas service, and those which are not. This disaggregation was done using assumptions about gas-serviced areas adopted in the B.C. Natural Gas Utilities Task Group,[5] with the further assumption that all new mainland apartment buildings will be built within reach of gas. The resulting gas service factors for single detached, single attached and mobile homes are as follows:

	Gas Service Factors
Vancouver Island	-
Lower Mainland	.95
Okanagan-West Kootenay	.90
East Kootenay	.70
Cariboo	.80
Omenica-Peace	.75
Skeena	.60

Separate capture rates for both gas-serviced and non-gas-serviced areas have been estimated on the basis of a survey of developers and utility companies. The relative prices of each fuel are also taken into account. Briefly, the survey indicated that within the electrical service area of B.C. Hydro, most new dwellings (with the exception of single attached homes) with access to gas will choose this fuel for both space and water heating. Where gas service is not available, electricity is now the favoured fuel, due to factors such as lower initial capital cost for the heating system, and convenience and cleanliness in use.

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[5] *Canadian Resourcecon* *Forecast of Natural Gas Requirements in British Columbia, 1973-1995, 1974.*

Within the common service area of West Kootenay Power and Light (W.K.P.L.) and Inland Natural Gas, electricity captures most of the heating and water heating market. The market common to W.K.P.L. and Columbia Natural Gas is split fairly evenly between electricity and gas. This situation is expected to prevail until at least 1987. Sometime in the 1980's, W.K.P.L. will have to start buying electricity from B.C. Hydro, causing the relative price advantage held by electricity in this area to diminish thereafter. Therefore, after 1987, gas is forecast to capture an increasing share of new space and water heating loads.

Oil and L.P.G.'s are expected to capture a minor portion of new heating loads in non-gas-serviced areas. Oil capture rates are low in this forecast in accordance with current trends. It is possible though that with greater public awareness of relative fuel prices, a switch back to oil will occur in non-gas serviced areas, although public uneasiness about oil supply may dampen such a shift. For illustrative purposes, Table 3.5 details the capture rates for both space and water heating in the Lower Mainland. Appendix C contains detailed capture rates for the remaining regions.

With respect to appliance requirements, a capture rate of 95 percent for electricity has been applied to all dwelling types except apartments, where appliances are assumed to be 100 percent electric. The balance of appliance needs will be supplied by natural gas (2%) and L.P.G.'s (3%). Appliance use of L.P.G.'s in the residential sector includes use in campers and trailers.

Output Energy Requirements per Dwelling Unit

For space heating in the residential sector, output energy requirements are a function of the insulating properties of the building envelope, its size, indoor and outdoor temperatures and the magnitude of internal heat loads. Each of the above factors has been taken into account in calculating future output heat requirements. Typical current insulation levels for new homes in each region are used for incremental homes built before 1980. After 1980 the new energy-efficient building code is assumed to be in place. This building code will require a minimum of double glazed windows with R-values

TABLE 3.5

LOWER MAINLAND CAPTURE RATES

(Percent of New Dwellings)

Space Heating	Single Detached	Single Attached	Apartments	Mobile
Gas Service				
Electricity	20	60	20	30
Natural Gas	80	40	80	50
RPP's	-	-	-	-
LPG's	-	-	-	20
No Gas Service				
Electricity	90	90	NA*	60
Natural Gas	-	-	NA	-
RPP's	10	10	NA	20
LPG's	-	-	NA	20
Water Heating				
Gas Service				
Electricity	20	60	-	30
Natural Gas	80	40	100	50
RPP's	-	-	-	-
LPG's	-	-	-	20
No Gas Service				
Electricity	100	100	NA	80
Natural Gas	-	-	NA	-
RPP's	-	-	NA	-
LPG's	-	-	NA	20

* Not Applicable

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of 28 for ceilings, 14 for walls and 7 for floors throughout most of the province. Higher levels will be required for colder areas. In the case of mobile homes, which will not be covered by the building code, current insulation levels are assumed to prevail throughout the forecast period.

For each dwelling type a unit of average size is used for calculation purposes. All units have a mean indoor temperature of 20°C, while outdoor temperatures are based on actual degree day data.

Table 3.6 contains the output heating requirements for homes built after 1980 when the new building code is in place. Output requirements for the current stock of homes and homes built prior to 1981 are higher.

Average output energy requirements for water heaters and different types of appliances were obtained from B.C. Hydro.[6] Water heating requirements are expected to stay constant over the forecast period, while appliance requirements show a small rise due to increased saturation levels (see Appendix B). New, more efficient appliances are now coming onto the market which will serve to check growth in energy use. Although it is not forecast here, it is possible that total

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[6] B.C. Hydro, Household Appliances: Average Annual Consumption and Operating Costs, 1974.

TABLE 3.6

PER UNIT OUTPUT ENERGY REQUIREMENTS FOR SPACE HEATING

(Billion joules/unit/annum)

Region	Single Detached	Single Attached	Apartments	Mobile
Vancouver Island	57.7	28.1	9.9	34.7
Lower Mainland	60.3	29.6	10.4	36.4
Okanagan-West Kootenay	81.7	42.9	14.9	43.5
East Kootenay	98.7	53.6	19.5	48.4
Cariboo	82.7	43.7	15.1	44.1
Omineca - Peace	104.8	55.7	25.7	64.1
Skeena	82.5	46.4	16.0	46.6

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energy consumption by appliances may actually decrease with future improvements in efficiency.

Per unit output energy requirements for water heating and appliances are forecast as follows:

Average Output Energy Requirements
Water Heating and Appliances
(Billion joules/unit/annum)

	Single Detached	Single Attached	Apartments	Mobile
Water Heating				
1977 +	25	22	20	22
Appliances				
1977-1981	21	17	13	17
1982-1992	23	18	14	18

Fuel Efficiency Factors

In order to convert output energy requirements to input requirements, actual operating efficiency factors for each fuel in each end-use have been applied. No conversion is necessary in the case of appliances, since it is assumed for ease of calculation that all fuels are 100 percent efficient in this end-use. For space heating and water heating, the fuel efficiency factors which have been used are as follows:

Fuel Efficiency Factors[7]

	Space Heating	Water Heating
Electricity	98	95
Natural Gas	70	70
Oil and L.P.G.	65	65

Over the forecast period it is likely that oil and gas fuel efficiencies will improve as more efficient furnaces and water heaters are developed. However, it is difficult to say when these improved furnaces and water heaters will become popular and what the magnitude of energy savings will be. No allowance has therefore been made in the forecast for energy savings arising from such improvements.

Conversions

Because of differences in residential fuel prices, heating and water heating fuel conversions in the existing housing stock are a factor which must be considered. In the Lower Mainland, for instance, 1,358 houses and 1,438 suites converted to natural gas in the twelve months prior to March 31, 1978.[8] These figures represent approximately

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[7] *British Columbia Energy Commission estimates.*

[8] *B.C. Hydro, Commercial Services Department.*

.5 percent of single detached homes and 1 percent of suites. By applying this percentage to the number of dwellings in each region as of 1976 within gas serviced areas, regional estimates of yearly conversions have been made.

Within the total B.C. Hydro electric service area, only 266 homes and 30 suites converted to electricity in the 1978 fiscal year.[9] Therefore, conversions to electricity are not considered in any region with the exception of Okanagan-West Kootenay. In this region one half of all conversions are assumed to be to electricity due to West Kootenay Power and Light's lower rates. All conversions are assumed to be from oil.

Retrofitting

This forecast takes actual energy consumption in a base year (1976) and adds forecast incremental requirements to those original figures. It is likely, though, that as homes are retrofitted to better insulation standards, original base year requirements will decline. The effect of retrofitting savings has been approximated by an annual decrease in energy use estimates of one percent of base year oil and gas consumption, starting in 1979. This approximation was derived assuming that 5 percent of existing oil and gas heated homes would retrofit each year with an average energy saving of 20 percent. Electricity and L.P.G.'s on the other hand, are not considered to have significant retrofit potential, in light of higher insulation levels for electrically heated homes and a wider variety of non-space heating applications.

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[9] *Ibid.*

V. The Forecast

Table 3.7 gives a detailed summary of the residential energy requirements forecast while Table 3.8 summarizes the forecast by fuel type. Electricity shows the highest rate of growth at an average of 3.1 percent per year over the forecast period. Natural gas consumption increases at an average rate of 1.8 percent per year whereas refined petroleum product consumption actually declines. Growth rates for electricity and natural gas are higher in the first five years to 1982 at 3.8 and 2.1 percent per annum respectively. This is largely due to the expected decrease in rates of household formation as population growth rates decline, but is also a result of the fact that no major impact from an improved building code is likely to be felt before 1982. Total residential energy requirements are forecast to increase at an annual average growth rate of 1.2 percent over the forecast period, with a short term rate of 1.3 percent.

TABLE 3.7

REGIONAL RESIDENTIAL ENERGY REQUIREMENTS FORECAST

(Quadrillion Joules)

Region	Fuel	1977	1978	1979	1980	1981	1982	1987	1992
Vancouver Island	Elec.	6.123	6.461	6.808	7.135	7.470	7.756	9.232	10.602
	Nat. Gas	-	-	-	-	-	-	-	-
	RPP's	12.691	12.731	12.651	12.568	12.486	12.402	11.990	11.655
	LPG's	2.403	2.423	2.443	2.462	2.481	2.501	2.605	2.708
Lower Mainland	Elec.	12.450	12.894	13.351	13.794	14.250	14.614	16.490	17.996
	Nat. Gas	38.259	39.366	40.145	40.840	41.557	42.144	45.201	48.326
	RPP's	8.880	8.617	8.267	7.917	7.567	7.217	5.468	3.719
	LPG's	1.745	1.752	1.759	1.766	1.774	1.781	1.820	1.858
Okanagan - West Kootenay	Elec.	5.090	5.330	5.576	5.825	6.080	6.317	7.539	8.580
	Nat. Gas	6.477	6.626	6.718	6.913	6.911	7.007	7.513	8.265
	RPP's	6.052	5.990	5.871	5.751	5.632	5.512	4.915	4.318
	LPG's	1.154	1.156	1.158	1.160	1.162	1.164	1.174	1.184
East Kootenay	Elec.	.708	.748	.790	.832	.875	.916	1.127	1.336
	Nat. Gas	1.450	1.482	1.502	1.523	1.544	1.564	1.670	1.774
	RPP's	.681	.675	.662	.649	.636	.623	.558	.493
	LPG's	.130	.131	.132	.133	.134	.135	.140	.145
Cariboo	Elec.	.673	.688	.704	.720	.737	.753	.836	.919
	Nat. Gas	.476	.520	.560	.601	.643	.683	.889	1.094
	RPP's	1.171	1.167	1.152	1.137	1.122	1.107	1.031	.955
	LPG's	.224	.227	.230	.233	.236	.239	.254	.269
Omineca - Peace	Elec.	1.397	1.438	1.480	1.523	1.567	1.607	1.817	2.026
	Nat. Gas	3.405	3.512	3.591	3.672	3.756	3.830	4.217	4.600
	RPP's	1.075	1.071	1.057	1.044	1.031	1.017	.952	.886
	LPG's	.211	.218	.225	.232	.239	.246	.284	.323
Skeena	Elec.	1.264	1.297	1.331	1.366	1.402	1.434	1.598	1.761
	Nat. Gas	.618	.675	.728	.782	.837	.884	1.129	1.372
	RPP's	1.765	1.766	1.750	1.734	1.718	1.701	1.620	1.538
	LPG's	.336	.340	.344	.348	.352	.356	.378	.400

TABLE 3.8

RESIDENTIAL SECTOR ENERGY REQUIREMENTS FORECAST

(Quadrillion Joules)

Year	Electricity	Natural Gas	RPP's	LPG's	Total
1977	27.705	50.685	32.315	6.203	116.908
1978	28.856	52.181	32.017	6.247	119.301
1979	30.040	53.244	31.410	6.291	120.985
1980	31.195	54.231	30.800	6.334	122.560
1981	32.381	55.248	30.192	6.378	124.199
1982	33.397	56.112	29.579	6.422	125.510
1987	38.639	60.619	26.534	6.655	132.447
1992	43.220	65.431	23.564	6.887	139.102

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CHAPTER 4

COMMERCIAL SECTOR ENERGY REQUIREMENTS

I. The Commercial Sector

The commercial sector, often described as the tertiary or service sector, refers to all activities other than manufacturing, forestry and mining. It includes finance and insurance, construction, agriculture, fishing, retail and wholesale trade, business and personal services, and government.[1] All energy consumed by these industries is included in the commercial sector with the exception of fuel used by the transportation and utility groups for public transportation, which is included in the transportation sector. Fuel consumed by the construction and agriculture industries for on-highway use is included.

Figure 4.1 summarizes the methodology employed in forecasting commercial sector energy requirements, whereby separate forecasts are made for building energy uses, non-building energy uses and street lighting.

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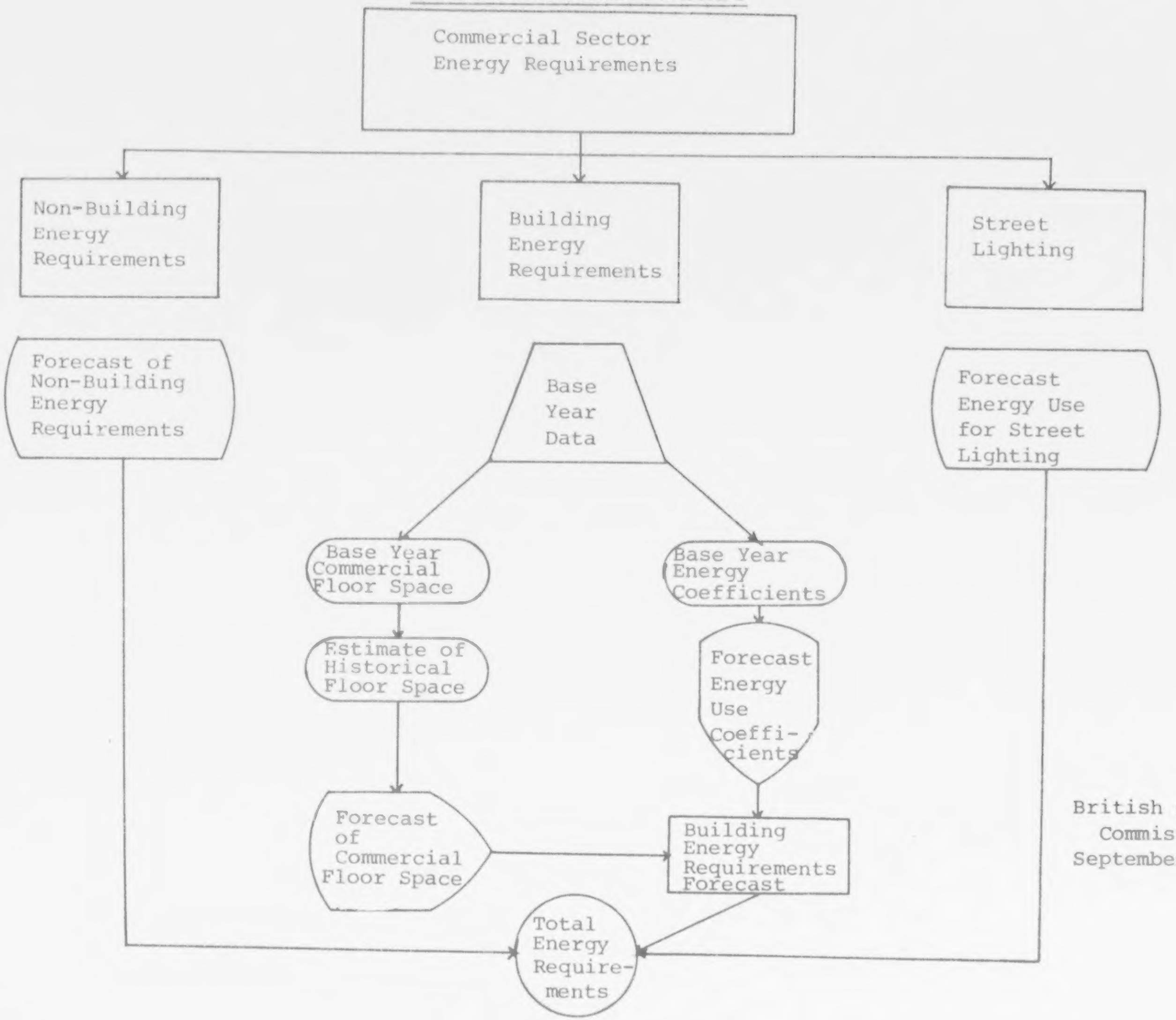
[1] *In Statistics Canada Standard Industrial Classification System, it corresponds to divisions 1, 3, 6, 7, 8, 9, 10, and 11. Consumption of energy to heat farm residences is included in the residential sector.*

FIGURE 4.1

FLOW CHART

COMMERCIAL ENERGY FORECAST


Commercial Sector Energy Requirements
Non-Building Energy Requirements
Building Energy Requirements
Street Lighting
Forecast of Non-Building Energy Requirements
Base Year Data
Forecast Energy Use for Street Lighting
Base Year Commercial Floor Space
Base Year Energy Coefficients
Estimate of Historical Floor Space
Forecast Energy Use Coeffi-cients
Forecast of Commercial Floor Space
Building Energy Requirements Forecast
Total Energy Require-ments

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II. Historical Fuel Consumption in the Commercial Sector

Estimation of historical fuel consumption for the commercial sector presents several difficulties, arising primarily from the inconsistent use of the term "commercial" in reported energy consumption data. Utilities and Statistics Canada typically maintain energy consumption data on the basis of rate classifications which do not correspond to industrial classifications. Large commercial users may for example, receive a bulk industrial rate, while small manufacturers may be allocated to the commercial category. Also, apartments--part of the residential sector--frequently receive a commercial rate.

To arrive at historical consumption figures consistent with the Energy Commission's definition of the commercial sector, consumption reported by the mining, manufacturing and logging industries and an estimate for apartment use (where applicable) was subtracted from the total of commercial and industrial gas, electricity and L.P.G. consumption as reported in the Statistics Canada catalogues. Refined petroleum products consumption figures for the commercial sector were obtained directly from the Statistics Canada catalogues and were then segregated into building and non-building use on the basis of a distribution derived from 1973 to 1976 data, which give separate consumption figures for commercial heating, and other industrial and commercial use. Tables 4.1(a) and 4.1(b) show the historical commercial fuel consumption estimated in this way.

III. Components of Commercial Sector Demand

Two principal components of energy consumption in the commercial sector have been identified in this report, and consumption in each has been forecast separately. Building-related energy use is the largest part of total demand, and includes energy for space heating, water heating, air conditioning, and lighting in commercial buildings. Non-building energy use includes such diverse applications as fuel for farm and construction machinery and for municipal vehicles. Energy requirements for these two principal use categories are combined with street lighting requirements to determine total commercial sector energy requirements.

TABLE 4.1(a)

HISTORICAL FUEL CONSUMPTION IN B.C.
(Commercial Sector)
(Quadrillion Joules)

	Natural Gas	Electricity	R.P.P.	L.P.G.	Total
1970	22.080	12.870	29.830	0.840	65.620
1971	26.450	14.140	30.680	1.060	72.330
1972	31.040	15.830	28.730	0.950	76.550
1973	31.780	19.100	30.690	1.370	82.940
1974	29.660	21.310	31.970	1.580	84.520
1975	29.780	21.200	29.330	1.580*	81.890
1976	35.040	24.590	26.380	1.580*	87.690

Source: Appendix D

* Estimated figures

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TABLE 4.1(b)

HISTORICAL FUEL CONSUMPTION IN B.C. BY COMPONENT

(Commercial Sector)
(Quadrillion Joules)

	Building Use	Non-Building Use	Street Lighting	Total
1970	43.860	21.230	0.530	65.620
1971	50.090	21.710	0.530	72.330
1972	55.690	20.230	0.630	76.550
1973	60.180	22.130	0.630	82.940
1974	60.960	22.940	0.630	84.320
1975	60.780	20.410	0.700	81.890
1976	69.290	17.670	0.730	87.690

Source: Appendix D

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IV. Buildings Energy Use Forecast

The forecast of energy requirements for commercial buildings proceeds through several steps and uses forecasts of commercial floor space together with projections of energy-use coefficients to derive the requirements forecast.

1. Commercial Floor Space

1.1 Base Year Floor Space Stock

Commercial floor space projections are made by stock adjustments to estimated base year (1976) floor space data for the Province. In order to allow for different rates of growth in different parts of the commercial sector, categories of commercial building stocks have been identified and their energy requirements individually estimated. These categories are retail and store based services, office based services (including government), tourist accommodation, educational institutions, hospitals, warehouses, and others.

Unfortunately, historical data on floor space for separate building categories is incomplete, and some judgement is required to provide a realistic historical floor space data series to use as a basis for forecasting future building stock changes.

Base year floor space data were obtained from several sources including the B.C. Buildings Corporation, the B.C. Department of Health, the Capital Regional District, Real Estate Board of Greater Vancouver, various municipalities, universities, colleges and all school districts in British Columbia. Total floor space in the Province at the end of 1976 is estimated to be 35 million square metres.

Table 4.2 provides a summary of estimated 1976 floor space for all types of buildings. For educational institutions and hospitals,actual floor space data are available. For the remaining building types separate tallies were made for Metro Victoria, the Greater Vancouver Regional District, and the rest of the Province. For Metro Victoria the actual floor space for each building category, excluding the "other" category, is known. For the GVRD, actual office and warehouse floor space data are available, but it was necessary to make estimates of floor space for retail and store based services, and tourist accommodation. For the rest of the Province, estimates are required for all categories except education and hospitals. For the "other" category, an estimate of 4.34 m^2/capita was derived. In future forecasts, it is anticipated that an improved data base will reduce the necessity for judgements and assumptions relating to commercial building floor space in the Province.

TABLE 4.2

ESTIMATED BASE YEAR FLOOR SPACE: BRITISH COLUMBIA 1976

(Square Metres)

Building Type	
Retail and Store Based Services	3,738,766
Office Based Services	3,193,100
Tourist Accommodation	758,330
Educational Instutitions	8,361,000
Hospitals (Acute & Extended Care)	1,172,398
Warehouses	6,479,561
Other	11,010 292
Total	34,713,447

Source: British Columbia Energy Commission estimates.

1.2 Historical Building Stock

In order that recent trends in the ratio of commercial floor space to population could be examined, it was necessary to construct historical floor space series for each category of commercial building. This was accomplished for each commercial building category except offices and schools in the following manner. First, 1976 appraisal costs (contained in Table 4.3) were applied to the 1976 floor space estimates to yield a total appraised value of floor space for 1976. From this, Statistics Canada value of construction data was sequentially subtracted to yield appraised values for each year prior to 1976, as far back as 1973.[3] The resulting appraised value series was then converted to an index which, when applied to the base year (1976) floor space estimate, produced historical floor space series. These are shown, by category, in Table 4.4.

For offices, historical floor space data was estimated on the basis of the information obtained from the Real Estate Board of Greater Vancouver and on the assumption that the base year office space split between GVRD and the rest of the Province applies to the office space for the years

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[3] *All values were discounted using a Statistics Canada non-residential construction cost index.*

TABLE 4.3

NON-RESIDENTIAL BUILDINGS APPRAISAL COSTS: BRITISH COLUMBIA - 1976

Building Type	Cost ($/m^2)
Retail Shops & Stores	$271.26
Warehouses	$154.25
General Office Buildings	$328.31
Medical Office Buildings	$352.85
Hotels and Motels	
Excellent	$433.80
Average	$297.09
Motels	$215.29
Hospitals	$433.80
Theatres	$495.16
Libraries	$342.52
Churches	$291.17
City Clubs	$355.22
Banks	$407.97
Mortuaries	$300.32

SOURCE: Steven Valuation Quarterly; Published by Marshall & Swift Publishing Co., 1976.

TABLE 4.4

HISTORICAL ESTIMATED COMMERCIAL FLOOR SPACE STOCK[1]

(Thousand m^2)

	Retail	Tourist Accommodation	Hospitals	Warehouses	Other Commercial
1973	2811	597	906	5546	9979
1974	3064	669	969	5879	10278
1975	3462	715	1056	6291	10689
1976	3739	758	1172	6480	11010

[1] Excludes educational facilities and office buildings.

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preceding 1976. In 1976, 60 percent of the base year office space was located in GVRD.

The historical office space data as compiled by the Real Estate Board could therefore be used to estimate the historical office space stock series. This stock series, along with the historical office space in GVRD, is presented in the following table.

Historical Office Space

(Thousand m^2)

Year	GVRD*	Estimated Office Space in B.C.
1973	1516	2526
1974	1678	2796
1975	1818	3030
1976	1916	3193
1977	2082	3470

* Source: Real Estate Trends in Metropolitan Vancouver by Real Estate Board of Greater Vancouver.

1.3 Building Stock Forecast

Retail shops, Tourist Accommodation, Warehouses, Hospitals, and other.

The building stock forecast is based on forecasts of floor space per capita, for each commercial category, applied to the population forecast.

Historically, floor space per capita coefficients for retail shops, tourist accommodation and warehouses have increased continuously. These trends, primarily attributable to increasing real disposable income, are expected to continue. The coefficients for these categories of floor space have therefore been forecast to continue to increase until 1987 in a manner consistent with recent historical experience, after which they have been held constant.

Hospital floor space per capita coefficients (which have also been increasing) are projected on the basis of future expansion plans for acute and extended care hospitals in the Province. Discussions with hospital construction authorities reveal that approximately 100 million dollars will be spent each year, for the next five years, on hospital construction and renovation. Using estimated construction costs, additions to the base year stock of hospital floor space were calculated, which provided a forecast of hospital floor space for the period 1977 to 1982. This forecast was then used to derive a forecast of hospital floor space per capita, which in turn provided a floor space forecast for the period 1982-1992.

The historical floor space per capita coefficients for the "other commercial" category do not reflect any discernable trend, and therefore a constant value of 4.34 m^2/capita--the historical average--is used to forecast floor space for this category.

Both the historical and projected floor space coefficients for these commercial building categories are presented in Table 4.5. The resulting floor space forecasts are contained in Table 4.8.

Office Buildings

Floor space projections for office buildings involve the estimation and projection of floor space per employee coefficients, and the evaluation of the share of population that is employed in office-based services. Statistics Canada data indicate that in 1971, the share of the total population that was employed in offices was 5.6 percent. This share has been steadily increasing since then, and in 1976 it was 7.2 percent. It is anticipated that this share will continue to increase, largely due to growth of the service industry. The office employment/population ratio has been forecast to increase from 0.072 in 1976 to 0.103 by 1987, and to 0.110 by 1992.

TABLE 4.5

HISTORICAL & PROJECTED FLOOR SPACE/CAPITA COEFFICIENTS

(m^2/person)

	Retail	Tourist Accomodation	Hospitals	Warehouses	Other Commercial
1973	1.21	0.26	0.39	2.40	4.31
1974	1.28	0.28	0.40	2.45	4.29
1975	1.41	0.29	0.43	2.56	4.35
1976	1.50	0.30	0.47	2.60	4.46
			FORECAST		
1977	1.55	0.33	0.50	2.60	4.34
1978	1.63	0.35	0.52	2.60	4.34
1979	1.71	0.37	0.54	2.61	4.34
1980	1.78	0.39	0.56	2.64	4.34
1981	1.86	0.41	0.59	2.67	4.34
1982	1.94	0.44	0.61	2.69	4.34
1987	2.34	0.54	0.76	2.83	4.34
1992	2.34	0.54	0.76	2.83	4.34

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The coefficient of floor space per employee[4] has also been constantly increasing over the historical period and is expected to follow the historical trend over the entire forecast period. The forecasts of both the office employment/population ratio and the floor space per employee coefficient are presented in Table 4.6, along with the forecast of office floor space derived using these two coefficients and the population forecast.

Educational Institutions

The forecast of floor space for educational institutions is based on school, college and university enrolment, and a forecast of floor space per student.

School enrolment projections were made by deriving a forecast of school age-specific population from the population forecast. Historically, approximately 82 percent of those of school age (5-19 years) attend schools in British Columbia. The remaining 18 percent have either graduated at an earlier age or have left for other reasons.

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[4] *The term employees here refers to only those persons employed in office-related jobs.*

TABLE 4.6

FLOOR SPACE PROJECTIONS FOR OFFICES

	Population ('000)	Employee/pop.	Employment* (# of employees)	Floor space per employee	Floor space (Thousand m^2)
1977	2492	0.072	179,424	19.34	3470
1978	2521	0.077	194,117	19.58	3801
1979	2550	0.080	204,000	20.19	4119
1980	2584	0.083	214,472	20.79	4459
1981	2619	0.085	222,615	21.40	4764
1982	2658	0.088	233,904	22.00	5146
1987	2855	0.103	294,065	25.03	7360
1992	3050	0.110	335,500	25.03	8398

* Includes those in Finance, Real Estate, Insurance, Public Administration, Doctors, Dentists, Accountants, Architects and Lawyer's Offices.

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It is assumed that the same 0.82 factor will apply over the forecast period. Application of this factor to the school-age specific population derived from the population forecast resulted in the school enrolment forecast. The forecast of school floor space is obtained by applying to the school enrolment forecast a floor space per student coefficient of 9.40 square metres, which was derived from 1976 data.

The foregoing, however, does not take into account any new schools that might be built in the province to meet the demand resulting from inter-regional shifts in the school age population. The construction of new schools to satisfy regional shifts in demand is very difficult to forecast. Information obtained from the Ministry of Education reveals that during 1979 approximately 34 million dollars will be allocated to construction of new schools in the province. This expenditure is expected to add about 83,000 square metres to existing school floor space. In the absence of any additional information, the basic forecast was adjusted assuming that a similar level of school construction will be maintained until 1987 to account for increased classroom space per pupil and for regional changes in population.

Floor space projections for post-secondary institutions (i.e. colleges, universities, etc.) are also based on enrolment figures. Since enrolment in post-secondary institutions is directly related to enrolment in schools, any trends in school enrolment are likely to manifest themselves in post-secondary enrolment. Over the period 1971-1976, school enrolment has increased at a rate of about one percent per year. Assuming that the rate of inflow of students in British Columbia schools is the same as the outflow, the rise in school enrolment during 1971-1976 will result in a similar increase in post-secondary enrolment five years later, i.e. during the period 1976-1981. Therefore, total enrolment in colleges and universities is forecast to increase at a rate of one percent per annum over the period 1976-1981. For the period 1981-1986, post-secondary enrolment is forecast to rise at a rate of about 0.2 percent per annum. After 1986, no further increase in college and university enrolment is expected, primarily due to the forecast decline in school enrolment over 1981-1987 period. (see Table 4.7).

The floor space projections for both schools and post-secondary institutions, as derived according to the above, are presented in Table 4.7; and for all commercial buildings in Table 4.8.

TABLE 4.7

FLOOR SPACE PROJECTIONS FOR EDUCATIONAL INSTITUTIONS IN B.C.

	Population[1] (5-19 years)	B.C. School Enrolment	Floor Space		
			Schools	Post Secondary Institutions	Total
				(Thousand m^2)	
1976	659,766	536,192	6,997	1,363	8,360
1977	649,808	532,843	6,997	1,377	8,374
1978	639,808	524,643	7,080	1,391	8,471
1979	629,892	516,511	7,163	1,405	8,568
1980	619,934	508,346	7,246	1,419	8,665
1981	609,976	500,186	7,329	1,433	8,762
1982	609,613	499,883	7,412	1,436	8,848
1987	607,799	498,395	7,661	1,447	9,108
1992	665,947	546,076	7,751	1,447	9,198

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[1] *Derived from our population forecast cf. Chapter II.*

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TABLE 4.8

FORECAST COMMERCIAL BUILDING FLOOR SPACE

(Thousand m^2)

	Retail	Offices	Tourist Accommodation	Hospitals	Education	Warehouse	Other
1976 (actual)	3739	3193	758	1172	8360	6480	11010
1977	3863	3470	822	1246	8374	6480	11341
1978	4109	3801	882	1311	8471	6555	11681
1979	4361	4119	943	1377	8568	6655	12031
1980	4599	4459	1008	1447	8665	6822	12392
1981	4871	4764	1074	1545	8762	6993	12747
1982	5156	5146	1169	1621	8848	7150	13147
1987	6681	7360	1542	2170	9108	8080	13817
1992	7136	8398	1647	2318	9198	8631	14232

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2. Energy-Use Coefficients Forecast

The base year average energy use coefficients were derived from a number of studies of offices, retail and other buildings; from telephone surveys; and from consultation with British Columbia Hydro and Power Authority sources. These coefficients are shown in Table 4.9. While these coefficients are estimates only, and may vary according to age and use made of commercial buildings, they nevertheless provide a useful first approximation for purposes of explaining energy consumption in this sub-sector, as Table 4.9 illustrates.

The energy coefficients shown in Table 4.9 represent average figures for the total existing building stock in 1976. On the basis of recent experience, it appears that new additions to the commercial building stock will be less energy intensive than buildings constructed during the last decade, but by virtue of more sophisticated heating, ventilation and air conditioning systems and higher lighting loads, will consume more energy per unit of space than older buildings. Average energy coefficents shown in Table 4.9 have therefore been held constant for both existing and new buildings until 1978, at which time coefficients for new buildings are assumed to be lower than for existing buildings.

TABLE 4.9

COMMERCIAL FLOOR SPACE AND ENERGY USE COEFFICIENTS FOR THE BASE YEAR 1976

Building Type	Estimated Floor Space	Estimated Energy-Use Coefficients	Estimated Energy-Use
	(m^2)	(Million joules $/m^2/y$)	(Quadrillion Joules)
Retail & Store Based Services	3,738,766	2800	10.470
Office Based Services	3,193,100	2450	7.825
Tourist Accommodation	758,330	1450	1.100
Educational Institutions	8,361,000	1500	12.540
Hospitals (acute & extended care)	1,172,398	2850	3.340
Warehouses	6,479,561	1000	6.480
Others	11,010,292	2500	27.525
Total Estimated			69.260
Actual			69.290

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To quantify the overall impact of energy conservation on building energy consumption in the commercial sector, a range of time paths for energy use coefficients has been defined. In defining these time paths, the effects of improvements in insulation characteristics and operating systems in existing buildings, and the introduction of a new building code or guidelines have been examined. In particular, buildings constructed in 1980 or thereafter will be characterized by higher insulation levels, less glass area and more efficient lighting, resulting in substantially greater energy efficiency.

The extent of the energy savings actually realized from implementation of a new code or energy guidelines will depend on the efficiency of its implementation. It appears that effective implementation could potentially reduce energy use in new buildings by as much as 30 percent to 60 percent, depending on the type of building. However, it is not expected that this potential will be wholly realized. Rather, the actual savings are expected to range between 20 percent and 40 percent. To accommodate these two extremes, two conservation scenarios--high and moderate--have been considered in the energy use coefficients forecast.

The assumptions embodied by the high conservation scenario are as follows:

i) buildings constructed in or after 1980 will use between 20 and 60 percent less energy than those constructed in 1976, depending on building type;

ii) buildings constructed in or prior to 1976 will experience, on average, a reduction of up to 20 percent in energy use reflecting more efficient building operation; and

iii) buildings constructed in the intervening years will to some degree reflect concerns about efficiency, with savings in energy of up to 40 percent, compared to buildings constructed in 1976 or previously.

The moderate conservation scenario assumes:

i) for buildings constructed in or after 1980, 20 to 40 percent reduction depending on building type, except warehouses and others;

ii) for buildings constructed in or prior to 1976, 5 to 12 percent reduction, except warehouses and others;

iii) for buildings constructed in the intervening period, up to 15 percent reduction, except warehouses and others.

It should be noted that although the effect of energy conservation will probably be observed in all types of commercial structures, substantial savings are expected only in retail space, office buildings, hospitals and schools. The high potential for savings in these buildings arises because, until recently, their design has incorporated excessive use of both windows and illumination--both areas where significant energy savings can be realized.

The energy-use coefficient forecasts are contained in Table 4.10 (a) and 4.10 (b).

TABLE 4.10(a)

FORECAST BUILDING ENERGY - USE COEFFICIENTS

(Million joules/m^2/y)
(High Conservation Scenario)

	Retail	Offices	Tourist Accomm.	Educational Institution	Hospitals	Ware-houses	Other
Buildings - existing in 1976							
- new constructions							
1977	2800	2450	1450	1500	2850	1000	2500
	2800	2450	1450	1500	2850	1000	2500
1978	2650	2350	1350	1425	2700	1000	2500
	2250	1850	1200	900	2280	900	2250
1979	2500	2220	1250	1350	2550	1000	2500
	2250	1850	1200	900	2280	900	2250
1980+	2375	2000	1160	1220	2500	1000	2500
	1550	1100	1000	600	1700	550	2000

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TABLE 4.10(b)

FORECAST BUILDING ENERGY - USE COEFFICIENTS
(Moderate Conservation Scenario)
(Million joules/m^2/y)

Buildings - existing in 1976
- new constructions

	Retail	Offices	Tourist Accomm.	Educational Institution	Hospitals	Ware-houses	Other
1977	2800	2450	1450	1500	2850	1000	2500
	2800	2450	1450	1500	2850	1000	2500
1978	2650	2350	1380	1425	2700	1000	2500
	2375	2100	1230	1275	2420	1000	2500
1979	2650	2250	1380	1360	2590	1000	2500
	2375	2100	1230	1275	2420	1000	2500
1980+	2650	2175	1380	1315	2590	1000	2500
	2250	1470	1160	900	1710	1000	2500

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3. Building Energy Requirements and Fuel Split

The final stage of the forecast is to project total energy requirements for commercial buildings and to disaggregate the projection into different fuels by applying a fuel split forecast.

The total building energy requirements were derived by first computing annual increments in the building stock for each of the seven building categories. Multiplying each annual increment in the building stock by the appropriate energy use coefficient and adding these increments to the base year consumption numbers from Table 4.9 provided high and moderate energy requirements forecasts. The forecast of building energy requirements is shown in Tables 4.11 (a) and 4.11 (b).

To disaggregate the total energy requirements into different fuels, the existing fuel split by building category was estimated. The following table contains that estimate. Non-electricity use includes consumption of natural gas, petroleum products and liquified petroleum gases.

TABLE 4.11(a)

FORECAST BUILDING ENERGY REQUIREMENTS
(Moderate Conservation Scenario)

(Quadrillion Joules)

	Retail	Offices	Tourist Accommodation	Educational Institu.	Hospitals	Ware-houses	Others	Total
1977	10.820	8.500	1.192	12.560	3.550	6.480	28.350	71.450
1978	10.840	8.880	1.210	12.060	3.530	6.560	29.200	72.280
1979	11.440	9.230	1.290	11.640	3.560	6.660	30.080	73.900
1980	11.970	9.490	1.360	11.350	3.680	6.820	30.980	75.650
1981	12.590	9.340	1.440	11.440	3.850	6.990	31.870	77.520
1982	13.230	10.500	1.550	11.510	3.980	7.150	32.870	80.790
1987	16.660	13.750	1.980	11.750	4.920	8.080	34.540	91.680
1992	17.680	15.280	2.110	11.830	5.170	8.630	35.580	96.280

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TABLE 4.11(b)

FORECAST BUILDING ENERGY REQUIREMENTS
(High Conservation Scenario)

(Quadrillion Joules)

	Retail	Offices	Tourist Accomm.	Educational Institu.	Hospitals	Ware-houses	Others	Total
1977	10.820	8.500	1.190	12.560	3.550	6.480	28.350	71.450
1978	10.810	8.790	1.180	12.020	3.520	6.550	29.120	71.940
1979	10.820	8.970	1.180	11.490	3.500	6.640	29.910	72.510
1980	10.740	8.640	1.180	10.460	3.620	6.730	30.630	72.000
1981	11.160	8.980	1.250	10.520	3.790	6.820	31.340	73.860
1982	11.600	9.400	1.350	10.570	3.920	6.910	32.140	75.890
1987	13.960	11.840	1.720	10.730	4.850	7.420	33.480	84.000
1992	14.670	12.980	1.830	10.780	5.100	7.720	34.310	87.390

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Base Year Fuel Split, 1976

Building Type	Electricity Use	Non-Electricity Use
Retail	55%	45%
Offices	45%	55%
Tourist Accommodation	25%	75%
Education	27%	73%
Hospitals	33%	67%
Warehouses	15%	85%
Others	36%	64%

This distribution is assumed to apply to all buildings over the forecast period. Buildings constructed in 1980 or after will use comparatively less energy, thereby generating substantial savings. Implicitly, these savings are assumed to be distributed pro rata between electricity use and non-electricity use, although savings may be marginally greater in non-electricity use. The forecast non-electricity requirements were further disaggregated into natural gas, refined petroleum products and liquified petroleum gas, on the assumption that 82 percent of the non-electricity use will be captured by natural gas, 15 percent by petroleum products and 3 percent by liquified petroleum gases. Only limited scope is foreseen in substituting other fuels for electricity in this sector.

The forecast energy requirements for commercial buildings by fuel type are presented in Tables 4.12(a) and 4.12(b).

TABLE 4.12(a)

TOTAL ENERGY REQUIREMENTS BUILDING COMPONENT

(High Conservation)

(Quadrillion Joules)

Year	Electricity	Natural Gas	R.P.P.	L.P.G.	Total
1977	25.820	37.420	6.840	1.370	71.450
1978	26.020	37.650	6.890	1.380	71.940
1979	26.310	37.880	6.930	1.390	72.510
1980	26.140	37.600	6.880	1.380	72.000
1981	26.900	38.500	7.050	1.410	73.860
1982	27.690	39.520	7.230	1.450	75.890
1987	31.090	43.380	7.940	1.590	84.000
1992	32.470	45.030	8.240	1.650	87.390

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TABLE 4.12(b)

TOTAL ENERGY REQUIREMENTS BUILDING COMPONENT
(Moderate Conservation)

(Quadrillion Joules)

Year	Electricity	Natural Gas	R.P.P.	L.P.G.	Total
1977	25.820	37.420	6.840	1.370	71.450
1978	26.177	37.803	6.915	1.383	72.278
1979	26.910	38.522	7.047	1.409	73.888
1980	27.535	39.462	7.219	1.444	75.660
1981	28.634	40.086	7.332	1.468	77.520
1982	29.716	41.879	7.661	1.532	80.788
1987	34.290	47.064	8.609	1.722	91.685
1992	36.132	49.322	9.022	1.804	96.280

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V. Forecast Non-Building Energy Requirements

Non-building related commercial sector energy requirements relate to gasoline, kerosene, diesel fuel, light fuel, and heavy fuel consumed by the construction, agriculture and government sectors for the operation of vehicles and machinery. Also included are municipal electricity requirements for the purpose of street lighting. The most convenient means of forecasting the former, given the difficulties of compiling an inventory of such machinery and equipment, is on the basis of a simple input-output coefficient.

The total output in construction, agriculture and government, the latter net of transfer payments, was forecast by multiplying these historic shares of Gross Provincial Product by the GPP forecast. For this purpose, the output shares of GPP that can be attributed to the individual industries were obtained from the B.C. Ministry of Economic Development.

The historical ratio of energy requirements to industry output yielded a declining trend. From 9.00 million joules per dollar of output in 1970 the coefficient dropped to 5.81 million joules in 1975. The future of this coefficient is unknown, and, for the purposes of this forecast, is assumed to remain constant at a level of 5.2 million joules per dollar of output for the duration of the forecast period. Multiplying this coefficient with the forecast of total output in construction, agriculture and government sectors provided the energy requirements forecast shown in Table 4.13.

Electricity used by government for the purpose of street lighting is also forecast here. In this case, a coefficient of energy use per capita was examined. As no trend was evident, a constant (the average over the historical period) was multiplied by the population forecast to yield the forecast in Table 4.13.

VI. Forecast-Total Commercial Sector Energy Requirements

Forecasts of total energy requirements for the commercial sector are derived by combining the "moderate" and "high" building energy requirements projections with a forecast of non-building energy use. For the moderate conservation case, the overall compound growth in energy use from 1976 to 1987 is 3.4 percent and from 1987 to 1992 it is 1.8 percent. The high conservation case, on the other hand, results in a compound growth rate of 2.2 percent over the entire forecast period. Both of these total energy requirements forecasts are shown in Table 4.14. Tables 4.15 (a) and 4.15 (b) contain these forecasts disaggregated by fuel type.

TABLE 4.13

COMMERCIAL SECTOR PROCESS AND MOTIVE ENERGY REQUIREMENTS

(Quadrillion Joules)

	Refined Petroleum Products	Electricity Street Lighting	Total
1977	21.040	0.740	21.780
1978	21.780	0.750	22.530
1979	22.550	0.760	23.310
1980	23.360	0.770	24.130
1981	24.210	0.780	24.990
1982	25.010	0.780	25.790
1987	29.780	0.840	30.620
1992	34.860	0.900	35.760

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TABLE 4.14

FORECAST TOTAL ENERGY REQUIREMENTS FOR COMMERCIAL SECTOR

(Quadrillion Joules)

	BUILDING USE		NON-BUILDING USE	TOTAL	
	Moderate Conservation	High Conservation		Moderate Conservation	High Conservation
1977	71.450	71.450	21.780	93.230	93.230
1978	72.278	71.940	22.530	94.808	94.470
1979	73.888	72.510	23.310	97.198	95.820
1980	75.660	72.000	24.130	99.790	96.130
1981	77.520	73.860	24.990	102.510	98.850
1982	80.788	75.890	25.790	106.578	101.680
1987	91.685	84.000	30.620	122.305	114.620
1992	96.280	87.390	35.760	132.040	123.150

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TABLE 4.15 (a)

FORECAST TOTAL ENERGY REQUIREMENTS FOR COMMERCIAL SECTOR BY FUEL TYPE

(High Conservation)

(Quadrillion Joules)

Year	Electricity	Natural Gas	R.P.P.	L.P.G.	Total
1977	26.560	37.420	27.880	1.370	93.230
1978	26.770	37.650	28.670	1.380	94.470
1979	27.070	37.880	29.480	1.390	95.820
1980	26.910	37.600	30.240	1.380	96.130
1981	27.680	38.500	31.260	1.410	98.850
1982	28.470	39.520	32.240	1.450	101.680
1987	31.930	43.380	37.720	1.590	114.620
1992	33.370	45.030	43.100	1.650	123.150

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TABLE 4.15 (b)

FORECAST TOTAL ENERGY REQUIREMENTS FOR COMMERCIAL SECTOR BY FUEL TYPE
(Moderate Conservation)
(Quadrillion Joules)

Year	Electricity	Natural Gas	R.P.P.	L.P.G.	Total
1977	26.560	37.420	27.880	1.370	93.230
1978	26.927	37.803	28.695	1.383	94.808
1979	27.670	38.522	29.597	1.409	97.198
1980	28.305	39.462	30.579	1.444	99.790
1981	29.414	40.086	31.542	1.468	102.510
1982	30.496	41.879	32.671	1.532	106.578
1987	35.130	47.064	38.389	1.722	122.305
1992	37.032	49.322	43.882	1.804	132.040

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CHAPTER 5

INDUSTRIAL SECTOR

I. Total Industrial Energy Requirements

Definition of Sector and Methodology

The industrial sector refers to manufacturing, mining and logging as defined in the Statistics Canada Standard Industrial Classification systems. In the requirements forecast, manufacturing is divided into eight sub-categories:

a) wood industries
b) pulp and paper
c) primary metals
d) non-metallic minerals
e) chemicals and chemical products
f) food and beverages
g) petroleum and coal products
h) other manufacturing activities.

In the following sections, these industries along with logging and mining are grouped into three main categories: forest sector; minerals sector; and other industrials sector.

Unfortunately there are problems of double counting some transportation energy requirements. Industrial energy demand for on-highway transport is included in this sector as well as in the transportation sector. The problem is that the transportation sector is defined in terms of type of use (regardless of type of user), whereas the industrial sector is defined by type of user (regardless of type of use). It should be noted, however, that this overlap is probably minimal.

To derive the industrial sector forecast, energy requirements in each of the component industries were estimated and then summed. The estimation procedure generally entailed forecasting the behaviour of production and the energy requirements per unit of output in the different industries. From the resulting total energy forecast, requirements for each energy type were then forecast by estimating the share of total energy supplied by each energy type. The future use of coal as an industrial energy source has been left to a later chapter in which the potential for coal use is discussed.

The forecasts were made primarily on the basis of consultations with persons closely associated with the different industries; some use was also made of historical trends. Much of the information supplied by industry is confidential and has been included only in an aggregate form.

To test the impact on energy requirements, a high growth forecast was made for the forest sector and the mining sector. This forecast allows for more rapid development in these two industrial sectors. For all other industrial groups a single forecast was made.

Total Industrial Sector Energy Forecast 1977-1992

Table 5.1 contains the forecast of total industrial energy requirements by industrial group. Tables 5.2 and

TABLE 5.1

FORECAST OF INDUSTRIAL SECTOR ENERGY REQUIREMENTS BY INDUSTRIAL GROUP

(Quadrillion Joules)

	1977	1978	1979	1980	1981	1982	1987	1992
Forest Industries								
Best estimate	260.96	268.09	276.74	285.08	294.94	304.16	348.24	390.15
High:	260.96	268.09	276.74	285.08	294.94	304.16	383.92	390.15
Mining								
Best estimate	20.20	23.08	21.89	21.21	22.37	23.75	32.35	38.02
High:	20.20	23.08	21.89	21.21	22.37	23.75	33.70	48.38
Non-Metallic Minerals	13.75	13.76	12.44	12.64	12.93	13.13	13.58	15.63
Primary Metals	44.09	44.37	45.39	46.37	47.32	48.87	58.94	84.79
Chemicals	8.47	10.24	10.58	10.93	11.29	11.67	12.52	14.12
Food & Beverages	6.32	6.39	6.47	6.56	6.65	6.75	7.24	7.74
Petroleum Coal Products	19.74	20.59	21.02	21.50	21.75	22.07	23.60	25.92
Other Manufacturing	4.17	4.45	4.74	5.05	5.39	5.74	7.90	10.87
Total								
Best estimate	377.70	390.97	399.27	409.34	422.64	436.14	504.37	587.24
High	377.70	390.97	399.27	409.34	422.64	436.14	541.40	597.59

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TABLE 5.2

FORECAST ENERGY REQUIREMENTS TOTAL INDUSTRIAL SECTOR, BY FUEL TYPE

(Quadrillion Joules)

(Best Estimate)

	Natural Gas	R.P.P.	Purch. Elec.	L.P.G.	Coal	Hog Waste Fuel/Liquors	Self-Gen. Elec. Hydro	Total
1977	64.64	80.29	44.50	2.04	6.52	150.98	28.73	377.70
1978	69.55	84.59	48.17	2.14	6.66	151.42	28.60	391.13
1979	69.73	85.15	48.85	2.17	6.74	157.34	29.31	399.29
1980	73.57	86.27	49.58	2.17	6.82	161.89	30.03	410.33
1981	76.19	84.60	51.48	2.24	7.21	170.52	30.39	422.63
1982	80.57	85.31	53.64	2.32	7.04	175.32	31.83	436.03
1987	81.90	89.26	63.84	2.49	8.29	221.50	37.17	504.45
1992	92.38	96.16	74.99	2.85	27.54	253.07	40.18	587.17

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TABLE 5.3

FORECAST ENERGY REQUIREMENTS TOTAL INDUSTRIAL SECTOR, BY FUEL TYPE

(Quadrillion Joules)

(High Growth)

	Natural Gas	R.P.P.	Purch. Elec.	L.P.G.	Coal	Hog Waste Fuel/Liquors	Self-Gen. Hydro Elec.	Total
1977	64.64	80.29	44.50	2.04	6.52	150.98	28.73	377.70
1978	69.55	84.59	48.17	2.14	6.66	151.42	28.60	391.13
1979	69.73	85.15	48.85	2.17	6.74	157.34	29.31	399.29
1980	73.57	86.27	49.58	2.17	6.82	161.89	30.03	410.33
1981	76.19	84.60	51.48	2.24	7.21	170.52	30.39	422.63
1982	80.57	85.31	53.64	2.32	7.04	175.32	31.83	436.03
1987	84.86	94.51	66.31	2.52	8.29	247.74	37.17	541.40
1992	95.24	99.30	79.32	2.91	27.54	253.07	40.18	597.55

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5.3 contain the best estimate and high industrial forecast by fuel type.

As indicated by Table 5.1, growth in consumption of energy by the industrial sector is forecast to average 2.9 percent according to the best estimate forecast from 1977 to 1992. Although the fifteen year average growth in energy requirements is of a similar magnitude in the high growth forecast, energy demand is forecast to grow more rapidly in the first ten years of the forecast period.

The forecast is characterized by a shifting of the relative importance of various industrial groups with the forest industries losing and the minerals industries gaining in importance.

Similarly, a shift in fuel shares is forecast to occur from refined petroleum products (RPP) and natural gas to hog fuel and coal. The shares of RPP's and natural gas fall from 20.9 percent and 17.0 percent to 16.0 percent and 15.6 percent respectively. On the other hand, the fuel shares of hog fuel and coal increase from 13.6 percent and 1.7 percent to 19.8 percent and 4.7 percent respectively. Purchased electricity's share of the total energy requirement is also forecast to increase slightly over the forecast period due to expansion in the mining and secondary manufacturing industries.

II. The Forest Sector

The forest sector in British Columbia is made up of three major industrial groups--logging, wood industries and paper and allied industries. These three industries account for approximately one half of total provincial manufacturing shipments,[1] and for about 70 percent of total industrial energy requirements.

The logging industry harvests the forests thus providing the primary input to the wood industries and the pulp and paper industries. The wood industries transform a portion of the annual forest harvest into lumber, plywood, shingles and other wood products. The process produces chips and sawdust, which become an input to the manufacture of pulp. Logs that cannot be sawmilled are chipped and become pulp furnish. Finished pulp is either exported or further processed to produce newsprint and other paper products.

In the process of transforming the output of the logging industry into marketable products, the forest sector manufactures a significant amount of waste which can be used as fuel to fulfill its own energy requirements. "Hog fuel" is simply mill residue which cannot be further used in the manufacture of lumber products or pulp, but is produced by both these processes, and can be burned in a boiler to produce either process steam or electricity. "Black liquor" is primarily made up of lignin, a substance found in wood, and is a by-product of the manufacture of chemical pulps. It, too, can be burned in a boiler to produce process steam or electricity.

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[1] *In 1977, these shipments had a value of approximately $5.2 billion, compared to an estimated total value for provincial manufacturing shipments of $10.2 billion.*

In light of the close relationship of the three components of the forest sector, the future production and energy requirements of each cannot be forecast independently. For this reason, the first part of this section will deal with future output levels of the forest sector; the latter part will then deal separately with the energy requirements of each component. Figure 5.1 summarizes the methodology employed.

A. Forecast of Physical Output

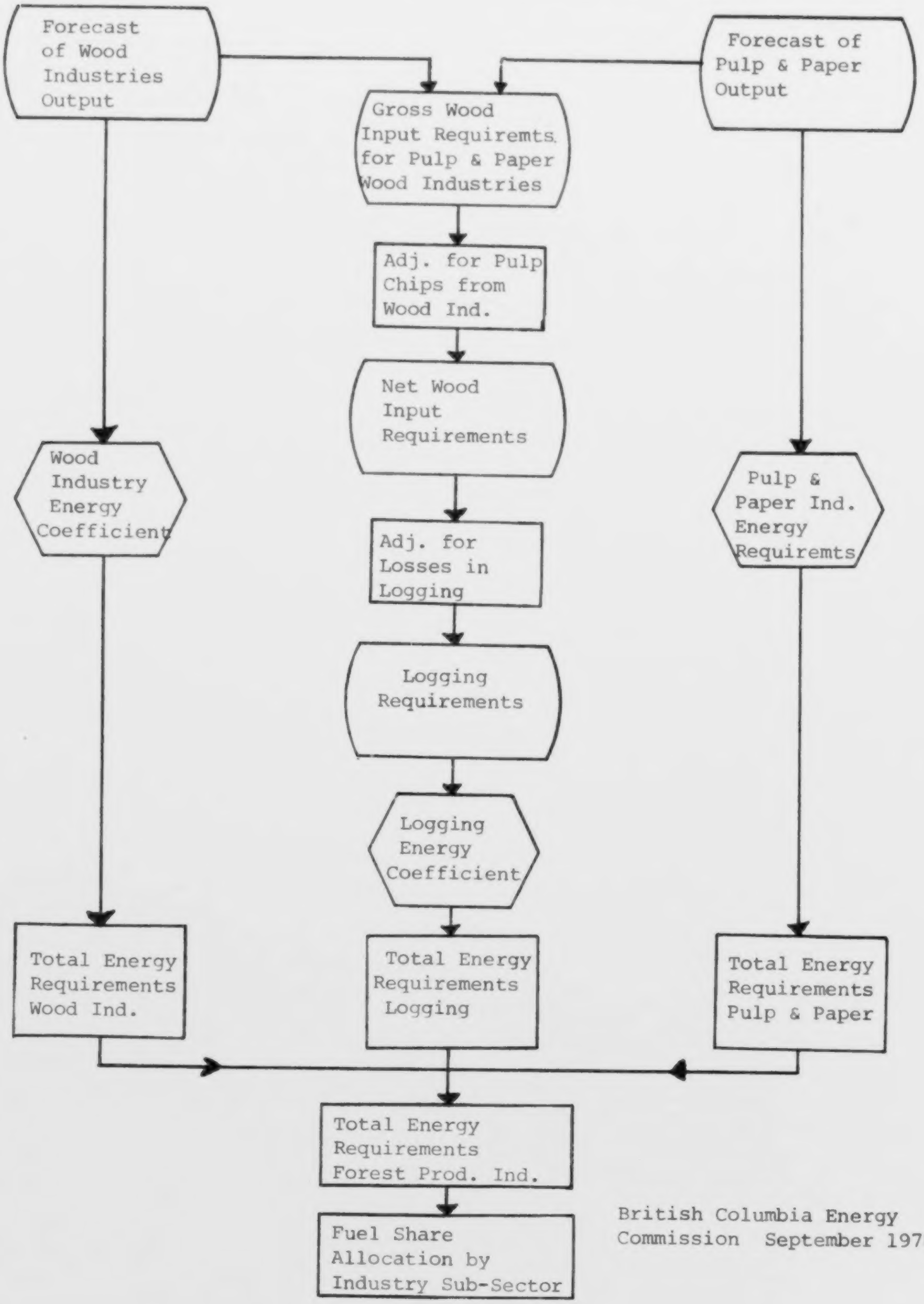
Logging Industry

Future growth in the output of the logging industry will be determined by two factors--the amount of wood available for cutting (natural resource constraint) and the needs of the wood, pulp and paper industries (market constraint).

Currently, over 95 percent of productive forest land in British Columbia is owned by the Crown. The harvest of this forest is managed on a sustained yield basis whereby

FIGURE 5.1

FOREST PRODUCTS INDUSTRY FORECAST: FLOW CHART


Forecast of Wood Industries Output
Forecast of Pulp & Paper Output
Gross Wood Input Requiremts. for Pulp & Paper Wood Industries
Adj. for Pulp Chips from Wood Ind.
Net Wood Input Requirements
Wood Industry Energy Coefficient
Adj. for Losses in Logging
Pulp & Paper Ind. Energy Requiremts
Logging Requirements
Logging Energy Coefficient
Total Energy Requirements Wood Ind.
Total Energy Requirements Logging
Total Energy Requirements Pulp & Paper
Total Energy Requirements Forest Prod. Ind.
Fuel Share Allocation by Industry Sub-Sector

British Columbia Energy Commission September 1978 the maximum annual harvest from each area is limited to the allowable annual cut (AAC), as calculated by the Forest Service for public units and by the licencees for private units.

The method of calculating the AAC has recently been questioned on the basis that it does not adequately reflect the true sustained yield potential of the forest base. In the report of the Royal Commission on Forest Resources, Dr. Pearse recommended sweeping changes in calculating allowable cuts to take account of all alternative uses of the resource base. He expressed the opinion that current AAC estimates are exaggerated for the coastal areas and the Kootenays (about 25 percent of productive forest land), though conservative for other Crown forest lands. According to Dr. Pearse, on an overall basis the existing calculation of the AAC provides a good estimate of the maximum potential of the provincial forest resource under sustained yield management.

In a report on intensive forest management in Canada, prepared for the Federal government in 1977, F.L.C. Reed and Associates Ltd.[2] have prepared their own zone-by-zone estimates of economically accessible AAC in British Columbia, as well as in other provinces. At existing AAC standards, the Reed Report estimates AAC at 69.92 million cubic meters in the province; at a closer utilization standard defined by Reed, economically accessible AAC rises to 81.12 million cubic meters. These estimates could be adjusted upwards, through the allowable cut effect,[3] under a program of intensive forest management on second and subsequent growth stands.

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[2] *F.L.C. Reed and Associates Ltd. Forest Management in Canada, Volume I, 1977.*

The above two reports highlight the difficulty of defining the limits to the resource base for harvesting in British Columbia. The Energy Commission, for the purposes of this forecast, has adopted two different approaches for estimating resource potential in the short and long run. In the short run, potential annual cut is assumed equal to the British Columbia Forest Service's estimate of the current technical feasibility of timber harvest on Public Sustained Yield Units (P.S.Y.U.), plus AAC for other regulated sustained yield units,[4] plus the 1973 harvest level on all properties not operating under this system.[5] This yields a total of 84.848 million cubic metres of gross log production, made up as follows:

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[3] *See Report of the Royal Commission on Forest Resources, Timber Rights and Forest Policy in British Columbia, Volume I (1976) pp 228-229 for a discussion of the allowable cut effect.*

[4] *Other regulated sustained yield units include Tree Farm Licenses and Farm Wood Lots and Tree Farms.*

from Public Sustained Yield Units	48.310
from Other Regulated Sustained Yield Units	21.866
from Unregulated Properties	14.672
	84.848

For the longer term potential annual cut, the approved AAC on P.S.Y.U.'s was substituted for the current potential of available cut. Substitution of this figure--64.458 million cubic metres--increases the maximum potential of gross log production to 100.997 million cubic metres. It is assumed that log production will, on average, increase at an annual rate of 2.3 percent per annum--a growth rate in line with industry expectations in other segments of the forest sector. At this rate of growth, the long-run maximum potential of the forest resource will be realized by 1992.

Table 5.4 shows the historical and forecast gross log production and net log availability. The lower net log

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[5] *1973 was a record year for logging production from unregulated forest lands. There is some indication, however, that accelerated cutting on unregulated Crown Grants and on Temporary Tenures outside of Tree Farms greatly exceeds sustained yield capacity, particularly in the Vancouver and Prince Rupert forest zones. This level of harvest may therefore not be sustainable on a long term basis. See F.L.C. Reed and Associates Ltd., Canada's Reserve Timber Supply, 1974.*

TABLE 5.4

HISTORICAL AND FORECAST GROSS LOG PRODUCTION AND NET LOG AVAILABILITY
(000 Cubic Metres)

	Gross Production	Net Availability
Historical[1]		
1967	44,536	37,544
1968	48,215	40,645
1969	53,528	45,337
1970	54,731	46,357
1971	56,558	48,073
1972	56,459	48,328
1973	70,146	59,834
1974	60,095	51,332
1975	50,081	42,820
1976	69,528*	59,356
1977	69,828*	59,704
Forecast		
1978	72,396	61,970
1979	74,367	63,732
1980	76,362	65,520
1981	78,492	67,424
1982	80,652	69,362
1987	90,412	77,754
1992	100,997	86,857

* Actuals

[1] *Source: Council of Forest Industries of B.C., Annual Report 1976.*

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availability figure arises from the use by the logging industry of a portion of its own production for boom sticks, bridge timber, and culverts; and from the waste and losses occuring between the forest and the market. According to a study be Reid, Collins and Associates,[6] coast log production has a recovery factor of 0.8 and interior log production has a slightly higher recovery factory of 0.9. In 1976, total net log availability was 85.4 percent of gross log production. This average recovery factor should increase slightly over the forecast period to about 86.5 percent in 1992, since most of the growth in the logging industry will occur in the interior regions where the average recovery factor is the highest.

Wood Industries

British Columbia's wood industries are heavily reliant on export markets. In 1976, 75 percent of lumber shipments, 90 percent of shingles and shake shipments, and 11 percent of plywood shipments were exported. Thus the future of these industries will depend on their ability to maintain or improve their position in world markets.

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[6] *Reid, Collins and Associates, Limited, The Availability of Hog Fuel for Generation of Thermal Power in British Columbia, June 1974.*

Lumber is used principally as a structural building material, and thus lumber demand is often related to single family housing starts. The province's lumber shipments are particularly sensitive to housing construction in the United States, since shipments to the U.S. account for roughly 60 percent of total provincial sales. The U.S. housing market is expected to remain relatively strong. As a structural material, lumber has been facing strong competition from alternatives and the amount of wood consumed per square metre of single family dwelling area has been declining. The declining trend in lumber content, however, is expected to reverse over the forecast period, due to the higher energy content and cost of most of the materials with which lumber competes.[7]

From 1967 to 1976 lumber production increased at an average annual rate of 4.6 percent with most of this growth arising in the interior. Provincial growth in lumber production over the forecast period is not expected to maintain this historical level, reflecting slower growth in our export customers' economies and the maturing of the province's wood industries. The long-run average growth in lumber production is forecast to be 3.7 percent per year from 1977 to 1982; and 3.2 percent per year for the remainder of the forecast period.

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[7] *For discussions on anticipated growth in lumber demand related to this factor, see Committee on Renewable Resources for Industrial Materials* *Renewable Resources for Industrial Materials**, Washington 1976.*

The lumber recovery factor (LRF) expresses the proportion of wood volume actually input to sawmills which is produced in the form of lumber. According to a report by Dobie and Wright, the average LRF in British Columbia is 44 percent.[8] The LRF is dependent on log diameter and the type of mill used: smaller diameter logs tend to have lower recovery factors. As the industry moves into second-growth logging the average diameter of logs will decrease, putting downward pressure on the recovery factor. Working against such a decline, however, is a move by industry to implement new technology to increase the recovery of smaller diameter logs. Taking these two factors in combination, the overall LRF will probably increase slightly over the forecast period. The Energy Commission has assumed that the lumber recovery factor will increase from about 44 percent in 1977 to 46 percent in

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[8] *J.Dobie and D.M. Wright, Conversion Factors for the Forest Products Industry in Western Canada, May 1972. The average LRF of 59 percent is adjusted to account for shrinkage in final lumber output.*

1982 and to 48 percent by 1987. The LRF is held constant at 48 percent after 1987.[9]

In 1976, 89 percent of the province's plywood shipments went to Canadian markets. This is the only component of the wood industries that is not heavily dependent on export markets. Plywood is mainly used as a building material, and thus expansion in the production of plywood will closely follow construction of new housing. According to industry sources, the plywood market is expected to remain strong to 1982. An average growth of 3 percent per annum to 1982 was suggested in discussion with industry representatives. From 1982 to 1992, growth in plywood production is expected to decline to 2 percent per annum to reflect the forecast slower growth in single attached and single detached housing units in British Columbia and elsewhere. Growth of this magnitude will be partly dependent on the industry improving its efficiency, thus maintaining its market against competition from United States suppliers.

The plywood recovery factory (PRF) is expected to decrease marginally over the forecast period. The average PRF is related to both the diameter and the species mix of the peeler logs. In the coast areas of the province, both these factors are expected to change. Douglas fir will be replaced by hemlock and balsam, and peeler log diameter is expected to decrease with this change in species and an increased volume of second growth logs. These changes suggest that the current coastal PRF of 44 percent will continue to decline. In the Interior, average peeler log diameters and species mix are not expected to change significantly. Thus, current interior recovery factors--38 to 44 percent depending on species--can be expected to prevail over the forecast period. It is assumed that the overall provincial PRF will fall from 44 percent in 1976 to 41 percent in 1981. The PRF is then maintained at 41 percent on the basis that new technology, introduced to improve the recovery efficiency of small diameter logs, will halt any further decline in the PRF.

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[9] *If in fact the LRF does not improve as outlined here, the forecast lumber production would require a higher log input, resulting in a higher proportion of the wood input to pulp production being supplied by wood chips rather than by roundwood.*

Production of shingles and shakes is heavily dependent on the export market. In 1976, 90 percent of British Columbia's shipments of shingles and shakes was exported to the U.S. Industry sources forecast that production of these products will grow at the same rate as production of plywood and veneer. It is also assumed that the current recovery factor[10] of 40.2 percent for shingles and shakes will continue over the forecast period. Table 5.5 contains the forecast of production in the wood industries and the associated log input requirement.

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[10] *J. Dobie and D.M. Wright, op.cit.*

Paper and Allied Industries

The pulp and paper industry in British Columbia is also an export-based industry. For this reasons future growth of this industry in the Province will be dependent on its ability to maintain or increase its share of world markets.

Although production declined slightly in 1977, markets for newsprint have been buoyant throughout 1978, with all plants working close to capacity. Discussions with industry representatives suggest, however, that Canada's share of the world market will gradually decline over the forecast period, from 37 percent in 1974 to 27 percent in 1990. British Columbia's newsprint customers, notably the United States, are increasing their newsprint capacity and are becoming more self-sufficient. Therefore, the outlook for sustained increases in newsprint exports over the short-term to 1982 is not promising. In the domestic market, the demand for newsprint is forecast to increase from the 1976 level of 135,000 tonnes to approximately 150,000 tonnes by 1980.

TABLE 5.5

WOOD INDUSTRIES PRODUCTION AND LOG INPUT REQUIREMENTS FORECAST

(Thousand m^3)

	Lumber Production	Log Input Requirements	Plywood and Veneer Production	Log Input Requirement	Shingles and Shakes Production	Log Input Requirement	Total Log Input Requiremt
1976	17,638	40,087	1,897	4,412	521	1,297	45,796
1977	18,300	41,217	1,954	4,588	535	1,331	47,136
1978	18,986	42,379	2,013	4,772	552	1,373	48,524
1979	19,697	43,576	2,073	4,959	569	1,416	49,951
1980	20,436	44,815	2,135	5,109	586	1,458	51,382
1981	21,203	46,094	2,200	5,367	603	1,501	52,962
1982	21,996	47,405	2,266	5,579	623	1,549	54,533
1987	26,408	55,016	2,502	6,102	688	1,711	62,829
1992	30,163	62,840	2,762	6,737	759	1,889	71,466

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Since the industry is already operating at near capacity levels, it was assumed that between 1978 and 1982 production of newsprint would remain constant at a level of approximately 150 thousand tonnes per year. Beyond 1982, it was assumed that capacity of 500,000 tonnes per year will be added and that by the end of the forecast period, this capacity would also be fully utilized.

The outlook for market pulp in British Columbia is brighter than for newsprint, although production levels did decline between 1976 and 1977. The province exports about 98 percent of its market pulp, mostly to Western Europe, Japan and the U.S., and these markets are expected to strengthen over the forecast period.

On the basis of discussion with the industry, it was assumed that market pulp production will increase from the 1976 base at 3-3 1/2 percent per annum to 1982, at which time current existing capacity will be fully utilized.[11]

In the short term, increases in production are assumed to be concentrated in coastal mills using oil, but by 1980 interior mills using natural gas are assumed to capture the greater share of incremental production. It has also been estimated that by the end of the forecast period, the available pulpwood supply can support three new pulp mills with a combined annual production capacity of 800,000 tonnes. By 1992, it was assumed that the industry would again be operating at full capacity.

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[11] *While 1976 has been used as the base year for forecasting, actual production levels for 1977 have been employed in place of the forecasted value for that year.*

Production of linerboard, kraft paper, and other paper products is also expected to experience slow growth over the next five years. Annual growth in domestic business, especially for linerboard, will be around 5 percent--slightly higher than 3.5 percent rate forecast for export trade. Fine paper production, which serves only the domestic market, is expected to remain static with any growth in demand being met by increased imports. In general, other paper production is forecast to increase at an annual rate of 2.8 percent.

According to a recent publication of the Council of Forest Industries,[12] the average raw wood requirements per tonne of product for the paper and allied industries are as follows: market pulp 6.245 m^3; newsprint 3.279 m^3; other paper 4.996 m^3. It was assumed that these factors will prevail over the forecast period, although there may be a slight decrease toward the end of the forecast period, due to current and proposed capital expenditures aimed at improving the efficiency of existing capacity. It is further assumed that 40 percent of log input to sawmills and 30 percent of log input to veneer mills will be available to pulp mills in the form of wood residue.[13] The remaining wood requirements will be filled by roundwood, that is, chips from whole logs.

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[12] *Council of Forest Industries, The Forest Industry of British Columbia, September 1976.*

Table 5.6 contains the forecast of pulp and paper production and related wood input requirements to 1992. Existing total pulp capacity in British Columbia is approximately 6,696 thousand tonnes per year. By 1992, total capacity is expected to increase to around 8,000 thousand tonnes. Production of pulp is forecast to reach 6,432 thousand tonnes by 1982 and 7,958 thousand tonnes by 1992.

The above forecast can be compared to estimates derived by Jegr and Thompson[14] and by Manning.[15] Jegr and Thompson forecast capacity of 10.1 million tonnes in 1990, assuming a 250 percent increase in pulpwood requirements in the province

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[13] *These are the proportions quoted by MacMillan Bloedel Ltd. in their submission to the Royal Commission on Forest Resources in Vancouver, November, 1975.*

[14] *K.M. Jegr and K.M. Thompson, The Canadian Pulp and Paper Industry: Threats and Opportunities 1980-1990, 1975.*

[15] *G.H. Manning, The British Columbia Pulp Industry Present Importance and Future Growth, November 1976.*

TABLE 5.6

MARKET PULP, NEWSPRINT AND OTHER PAPER PRODUCTION AND WOOD INPUT REQUIREMENTS FORECAST

	Market Pulp[1] (000 ADT)	Wood Input (000 m^3)	Newsprint (000 tonnes)	Wood Input (000 m^3)	Other Paper (000 tonnes)	Wood Input (000 m^3)	Total Pulp[1] (000 ADT)
1976*	3447	21,526	1327	4,352	636	3,178	5410
1977**	3020	18,860	1288	4,224	705	3,522	5013
1978	3674	22,944	1497	4,909	674	3,367	5844
1979	3794	23,694	1497	4,909	695	3,472	5946
1980	3917	24,462	1497	4,909	716	3,577	6130
1981	4044	25,255	1497	4,909	737	3,682	6278
1982	4176	26,079	1497	4,909	759	3,792	6432
1987	4443	27,747	1997	6,548	891	4,451	7331
1992	4976	31,075	1997	6,548	985	4,920	7958

* Actuals, Canadian Pulp and Paper Association. ** Preliminary estimates by the Energy Commission

1. Air Dried Tonnes.

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between 1970 and 1990; Manning, in contrast, estimates capacity at 7.2 million tonnes in 1990, based upon present harvesting techniques, allowable cut levels and manufacturing processes. The Manning estimate, however, may be low, owing to such factors as creation of additional PSYU's in British Columbia, additional resource availability from Tree Farm Licenses and improved recovery in harvesting operations.

B. Energy Requirements Forecasts

Having made production forecasts for each of the three component industries of the forest sector, it is now possible to make an assessment of the future energy requirements of each component. This second section, therefore, deals independently with each component to produce individual requirements forecasts.

Logging Industry

Table 5.7 contains data on historical gross log production and energy usage, and the resulting energy coefficient per cubic metre of logs produced.

Table 5.7 reveals wide fluctuations in the value of the co-efficient after 1971, although the value appears to be increasing over time. These fluctuations are thought to be due to problems of inventory adjustment in reporting purchases of refined petroleum products. The growth in energy

TABLE 5.7

HISTORICAL ENERGY USE BY THE B.C. LOGGING INDUSTRY

	Gross Log Production[1] (thousand m^3)	Energy Consumption[2] (Quadrillion Joules)	Energy Coefficient (Mj /m^3)
1965	43415	5.613	129.0
1966	45380	5.887	129.7
1967	44536	6.077	136.5
1968	48215	6.752	140.0
1969	53528	7.596	141.9
1970	54731	8.029	146.7
1971	56558	8.873	156.9
1972	56459	10.234	181.3
1973	70146	11.184	159.4
1974	60095	11.669	194.2
1975[3]	50081	7.016	140.1

1. Source: Table 5.4
2. Statistics Canada unpublished data.
3. Statistics Canada Catalogue 57-208

use per cubic metre that has been experienced by the logging industry is primarily the result of two factors:

i) As the industry has grown, its operations have been extended into more remote areas. The increased hauling distances required to recover the felled logs necessitated an increased use of energy per cubic metre of logs.

ii) The industry was also becoming more mechanized over this period, with a consequent increase in energy usage.

These factors, combined with the impact of energy conservation, will determine the future energy use per cubic metre. It has been forecast that the logging industry will grow at an average annual rate of 2.3 percent to 1992. This growth will require that the industry initially log more remote areas, thus putting upward pressure on the energy coefficient. Later in the forecast period, this pressure may be partially offset by increased harvesting of second growth stands in closer proximity to existing mills.

The logging industry is currently introducing energy conservation measures aimed at reducing fuel consumption in the woods. These measures include switching off vehicle engines instead of letting them idle, enforcing lower speeds on logging roads and recycling machine oil as fuel for shop heating systems (although the latter application may be constrained by considerations of pollution control).

Discussions with the industry confirm the difficulty of forecasting the cumulative future effect of these factors. Industry sources suggested that, on the average, the savings from conservation measures could offset the increased energy required for logging more remote areas and further industry mechanization. Therefore, it was assumed that the energy coefficient will remain constant at the 1976 level over the forecast period.

The 1976 energy coefficient was estimated on the basis of averaging 1973 and 1974 production and energy use data; 1975 was not used in light of disruptions in the forest sector arising from labour-management problems. The resulting estimate of 175.5 MJ per cubic metre of logs produced should also reflect the interplay of other variables, such as weather, which affect energy use in the logging industry.

Petroleum products have historically dominated energy use by the logging industry (97.8 percent in 1974 and 96.5 percent in 1975), and this trend is expected to continue. The primary use of energy in the industry is the operation of heavy equipment such as logging trucks, log loaders, tractors and other equipment powered by internal combustion engines. The historical market share of 97 percent refined petroleum products, 1.5 percent electricity and 1.5 percent liquified petroleum gases is therefore likely to prevail over the forecast period.

Table 5.8 contains the forecast of gross log production, energy requirements by type and energy usage per unit of output.

Wood Industries

Table 5.9 contains historical purchased energy consumption by wood industries, historical production of lumber, plywood, shingles and shakes and the implied per unit requirement for purchased energy. Table 5.10 contains a breakdown of historical purchased energy consumption by fuel type.

As shown in Table 5.9, the purchased energy coefficient more than doubled over the 1965-75 period. This increase probably reflects decreased lumber yields per unit of wood input and the adoption of energy-intensive lumber drying processes.

The wood industries also use a significant amount of hog fuel in their production processes, use of which is not included in Table 5.9. Below is a recent estimate of the per unit total energy requirement in the wood industries.[16]

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[16] *Council of Forest Industries, Submission to the B.C. Energy Commission 1978 Oil and Natural Gas Price Inquiry, May 1978.*

TABLE 5.8

FORECAST OF ENERGY USAGE IN THE LOGGING INDUSTRY

	Gross Log Production ('000 m^3)	Energy Coefficient (MJ/m^3)	R.P.P.	Electricity	LPG	Total Energy
				(Quadrillion Joules)		
1976	69,528*	175.5	11.836	0.183	0.183	12.202
1977	69,828*	175.5	11.887	0.184	0.184	12.255
1978	72,393	175.5	12.324	0.191	0.190	12.705
1979	74,367	175.5	12.659	0.196	0.196	13.051
1980	76,362	175.5	13.000	0.201	0.201	13.402
1981	78,492	175.5	13.362	0.207	0.206	13.775
1982	80,652	175.5	13.729	0.213	0.212	14.154
1987	90,412	175.5	15.391	0.238	0.238	15.867
1992	100,997	175.5	17.193	0.266	0.266	17.725

* Actual

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TABLE 5.9

HISTORICAL PRODUCTION AND ASSOCIATED PURCHASED ENERGY CONSUMPTION IN THE WOOD INDUSTRIES*

	Production[1] ('000 m^3 SWE)	Energy Consumption[2] (Quadrillion Joules)	Energy Coefficient (Quadrillion Joules/ Million Cubic Metres)
1965	13.747	6.657	.48
1966	13.590	7.132	.52
1967	13.310	6.763	.51
1968	14.540	7.976	.55
1969	14.418	9.538	.66
1970	14.104	9.886	.70
1971	16.367	12.576	.77
1972	17.428	15.636	.90
1973	19.142	17.482	.91
1974	16.250	17.120	1.05
1975	13.871	14.638	1.05

1. Source: Statistics Canada Catalogue 35-204 for lumber and shingles and shakes production. 35-001 for plywoods and veneer production.
2. Statistics Canada Energy Service Bulletin Catalogue 57-002, Figures do not include use of hog fuel. 57-208 for 1975.

* Lumber, plywood, shingles and shakes.

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Industry	Energy Requirements
Lumber	1.603)
Plywood	2.980) Billion joules per cubic metre
Shakes & Shingles	1.483)

On the basis of these coefficients, it was estimated that in 1975 over 40 percent of the wood industries' energy consumption came from hog fuel. The hog fuel is used to generate steam which in turn is used both for power generation and for process heat.

In recent years, pollution control costs have encouraged a trend away from self-generation of electricity from hog fuel towards using purchased electricity. Information received from the industry suggests that in the short term future, new sawmills will use purchased electricity instead of self-generated electricity. For the purpose of this forecast, it was assumed that the annual amount of hog fuel used to 1982 will stay constant at the 1976 level (estimated to be equivalent to 13.880 quadrillion joules).

The effects of factors which may change the energy coefficient are difficult to estimate. A continuation in the trend toward more energy intensive processes may well be offset by conservation efforts aimed at reducing energy consumption. It was assumed that the energy coefficient for the wood industries will remain constant at current levels throughout the forecast period.

Over the historical period shown in Table 5.10, natural gas has been increasing its share of energy supply to the wood industries primarily at the expense of refined petroleum products. It is expected that this trend will continue over the forecast period. Both L.P.G. and electricity have maintained constant shares over the historical period. Due to the current trend towards the use of purchased rather than self-generated electricity, it is expected that purchased electricity will increase its share of energy supply to the wood industries until 1982, primarily at the expense of hog fuel. The share of L.P.G. has been maintained at its estimated historic level of 3 percent.

After 1982, the relative cost of electricity and other fuels should increase the attractiveness of hog fuel even with the restrictions of pollution control. Therefore, it was assumed that the incremental energy requirement between 1982 and 1987 will be completely supplied by hog fuel. This assumption allows for some conversion in existing plants to hog fuel boilers plus new facilities to be constructed with hog fuel as their only energy supply. No specific

TABLE 5.10

HISTORICAL PURCHASED ENERGY CONSUMPTION BY FUEL TYPE,WOOD INDUSTRIES

(Quadrillion Joules)

	R.P.P.	L.P.G.	Natural Gas	Electricity	Total
1965	3.439	.422	.654	2.142	6.657
1966	2.986	.454	1.298	2.395	7.132
1967	2.195	.464	1.340	2.648	6.763
1968	2.363	.538	2.289	2.785	7.976
1969	2.923	.675	2.796	3.144	9.538
1970	3.028	.696	2.796	3.366	9.886
1971	3.292	.780	4.579	3.925	12.576
1972	4.157	.960	6.035	4.484	15.636
1973	4.030	.950	7.227	5.275	17.482
1974	3.976	1.070	6.997	5.075	17.120
1975	2.855	.586	6.143	5.054	14.638

Source: Statistics Canada
Fuel and electricity purchased and consumed by manufacturing industries
Catalogue 57-002, and 57-208.

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allowance has been made, however, for introduction of wood gasification technology, which might result in hog fuel capturing an increasing share of kiln drying and similar loads. Fuel shares for 1992 are assumed to be the same as in 1987.

Table 5.11 shows forecast energy consumption, by fuel type, in the wood industries.

Pulp and Paper

Table 5.12 shows historical consumption of purchased energy in the pulp and paper industry in British Columbia for the years 1965 to 1975. The industry also consumes energy from waste pulping liquors, and from hog fuel, which together are estimated to account for over 64 percent of total energy consumption. Other than summary industry data for 1977 supplied by the Canadian Pulp and Paper Association, figures on the historical consumption of these fuels are not available.

Future energy requirements by these industries were based primarily on specific energy use coefficients which were estimated for 1976 to be as follows:

TABLE 5.11

FORECAST ENERGY CONSUMPTION IN THE WOOD INDUSTRIES

Energy Requirements (Quadrillion Joules)

	Production[1] ('000 m3 SWE)	Hog Fuel	R.P.P.	L.P.G.	Natural Gas	Purchased Electricity	Total Energy
1976	20,056	13.88	4.90	1.35	8.33	6.24	34.70
1977	20,789	13.88	5.13	1.38	8.94	6.62	35.95
1978	21,551	13.88	5.14	1.41	9.58	7.24	37.25
1979	22,339	13.88	5.23	1.45	10.26	7.78	38.60
1980	23,157	13.88	5.32	1.47	10.97	8.36	39.99
1981	24,006	13.88	5.38	1.51	11.71	8.96	41.44
1982	24,885	13.88	5.42	1.55	12.49	9.59	42.94
1987	29,598	20.84	5.42	1.55	12.49	9.59	49.89
1992	33,684	24.12	6.27	1.79	14.45	11.09	57.71

1. From Table 5.5, includes lumber, plywood, shingles and shakes.

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TABLE 5.12

HISTORICAL CONSUMPTION OF PURCHASED ENERGY BY B.C. PULP AND PAPER INDUSTRY

(Quadrillion Joules)

	R.P.P.	Natural Gas	Electricity	Total
1965	27.748	2.743	7.280	37.877
1966	29.647	5.381	8.757	43.890
1967	32.496	7.702	9.918	50.221
1968	37.455	7.702	10.867	56.235
1969	35.239	15.087	12.239	62.671
1970	31.757	17.936	11.711	61.721
1971	34.184	19.413	13.294	67.207
1972	34.752	20.769	15.291	70.963
1973	36.751	25.842	13.337	76.057
1974	41.875	27.289	12.819	82.130
1975*	35.265	21.685	11.948	69.019

SOURCE: Statistics Canada Energy Bullitin, Catalogue 57-002 and 57-208.

**The drop in energy consumption in 1975 was due mainly to industry shut downs due to labour-management problems.*

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Product	Energy Coefficient (Billion joules per tonne)	
	Heat as Fuel	Electricity
Pulp	46.750	1.417
Newsprint	15.553	6.747
Unbleached Pulp	35.223	1.417
Groundwood Pulp	-	6.747

Table 5.13 contains the forecast of energy requirements for the pulp and paper industry as estimated from the above coefficient. The total energy requirement was broken down by fuel type and the requirement for thermal generation of electricity is shown separately. The predicted energy consumption forecast in this sector represents an estimate of the gross quantities of energy which might be consumed in the production of a particular mix of finished products. Changing the assumed product mix could alter the forecast, particularly the composition of the total energy demand. Although the industry has established a target to reduce per unit energy consumption by 8-10 percent by 1980, the effects of this program have not been included due to some uncertainty concerning the base year energy co-efficients.

As was mentioned earlier, the pulp and paper industry in British Columbia already has reached a high degree of energy self-sufficiency and this self-sufficiency is forecast to increase to 73 percent by 1992. The amount of black liquor

TABLE 5.13

FORECAST ENERGY CONSUMPTION IN THE PULP AND PAPER INDUSTRY
(Quadrillion Joules)

			Heat Source by Fuel					Heat Distrib.			
	Product	Production (000 tonnes)	Nat. Gas	R.P.P.	Hog Fuel	Waste Liquor	Total Heat	To Process	To Elec. Generation	Purch. & Hydro Self-Gen. Elec.	Total Energy
1976*		5410	22.17	34.25	37.03	92.04	185.49	176.41	9.08	16.91	202.40
1977**		5013	23.82	34.50	37.00	100.10	195.41	187.21	8.20	17.34	212.75
1978	Market Pulp	3674	22.70	26.60	28.70	84.77	162.79	155.89	6.90	5.21	168.00
	Newsprint	1497	-	6.53	9.41	7.60	23.53	20.91	2.62	10.10	33.63
	Other	674	2.14	4.81	-	7.06	14.01	14.01	-	2.51	16.52
		5845	24.84	37.94	38.11	99.43	200.33	190.81	9.52	17.82	218.15
1979	Market Pulp	3794	21.64	28.91	30.62	87.54	168.70	161.57	7.13	5.38	174.08
	Newsprint	1497	-	5.52	10.38	7.60	23.50	20.88	2.62	10.10	33.60
	Other	695	2.14	5.29	-	7.32	14.75	14.75	-	2.65	17.40
		5986	23.78	39.72	41.00	102.46	206.95	197.20	9.75	18.13	225.08
1980	Market Pulp	3917	22.67	29.66	31.94	90.39	174.65	166.80	7.85	5.23	179.88
	Newsprint	1497	-	5.52	10.38	7.60	23.50	20.88	2.62	10.10	33.60
	Other	716	2.51	5.28	-	7.70	15.44	15.49	-	2.70	18.19
		6130	25.18	40.46	42.32	105.69	213.64	203.17	10.47	18.03	231.67
1981	Market Pulp	4044	24.31	28.00	35.72	93.32	181.35	173.26	8.09	5.39	186.75
	Newsprint	1497	-	4.35	11.92	7.60	23.87	21.25	2.62	10.10	33.96
	Other	737	2.90	5.27	-	8.08	16.25	16.25	-	2.76	19.01
		6278	27.21	37.62	47.64	109.00	221.47	210.76	10.71	18.25	239.72
1982	Market Pulp	4176	26.84	27.75	36.63	96.36	187.58	179.22	8.36	5.57	193.18
	Newsprint	1497	-	4.00	12.38	7.60	23.97	21.35	2.62	10.10	34.07
	Other	759	3.30	5.25	-	8.47	17.02	17.02	-	2.83	19.85
		6432	30.14	37.00	49.01	112.43	228.57	217.59	10.98	18.50	247.07

Con't

Table 5.13 continued

			Heat Source by Fuel					Heat Distrib.		Purch.& Hydro	
	Product	Production (000 tonnes)	Nat. Gas	R.P.P.	Hog Fuel	Waste Liquor	Total Heat	To Process	To Elec. Generation	Self-Gen. Elec.	Total Energy
1987	Market Pulp	4443	19.35	24.67	58.37	102.54	204.93	196.06	8.87	5.91	210.83
	Newsprint	1997	-	4.43	18.85	10.14	33.42	29.93	3.49	13.47	46.90
	Other Paper	891	4.43	6.37	-	10.76	21.51	21.56	-	3.19	24.75
		7331	23.78	35.47	77.22	123.44	259.91	247.55	12.36	22.57	282.48
1992	Market Pulp	4976	20.56	24.67	72.52	114.83	232.59	222.72	9.86	6.58	239.17
	Newsprint	1997	-	4.43	18.85	10.14	33.42	29.93	3.49	13.47	46.89
	Other Paper	985	5.42	7.22	-	12.61	25.25	25.25	-	3.40	28.65
		7958	25.98	36.32	91.37	137.58	291.26	277.90	13.35	23.45	314.71

* Preliminary estimate by B.C.E.C.

** Based upon summary industry data supplied by Canadian Pulp and Paper Association.

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used as an energy source by the industry is determined by the level of chemical pulp production and will therefore increase as production increases. A substantial quantity of fuel oil and natural gas could still be displaced by more hog fuel consumption after 1992. The rate of displacement, however, depends upon many factors including the availability of hog fuel, relative cost of hog fuel versus natural gas and fuel oil and the capital cost of hog burning equipment. The rate of displacement included in this forecast is based upon currently active or contemplated hog fuel conversion projects in the province. For new pulp mills it was assumed that 85 percent of the heat requirement (net of waste liquor) would be supplied by hog fuel with the remaining 15 percent supplied by natural gas. It is possible, however, that by the end of the forecast period pulp mills may be able to operate completely on hog fuel. This could happen if present problems of using hog fuel to fire the lime kilns are overcome by new technology.

Total Energy Requirements: the Forest Sector

Table 5.14 contains the best estimate forecast of total energy requirements by the forest sector by fuel type. Energy requirements are forecast to grow at a compound annual rate of 2.8 percent over the period 1976 to 1992. Figure 5.2 shows diagramatically the change in fuel shares over the forecast period.

TABLE 5.14

FORECAST ENERGY REQUIREMENTS IN THE FOREST SECTOR BY FUEL TYPE

(Quadrillion Joules)

	Electricity							
	Purchased	Self-Gen. Hydro	Natural Gas	R.P.P.	L.P.G.	Hog Fuel	Waste Liquor	Total
1976	20.98	2.35	30.50	50.99	1.53	50.91	92.04	249.30
1977	21.79	2.35	32.76	51.52	1.56	50.88	100.10	260.96
1978	22.90	2.35	34.42	55.40	1.60	51.99	99.43	268.09
1979	23.76	2.35	34.04	57.61	1.64	54.88	102.46	276.74
1980	24.24	2.35	36.15	58.78	1.67	56.20	105.69	285.08
1981	25.07	2.35	38.92	56.36	1.72	61.52	109.00	294.94
1982	25.95	2.35	42.63	56.15	1.76	62.89	112.43	304.16
1987	30.05	2.35	36.27	56.28	1.79	98.06	123.44	348.24
1992	32.46	2.35	40.43	59.78	2.06	115.49	137.58	390.15
Ave. Annual Growth Rate	(2.8%)	(0.0%)	(1.8%)	(1.0%)	(1.8%)	(5.3%)	(2.5%)	(2.8%)

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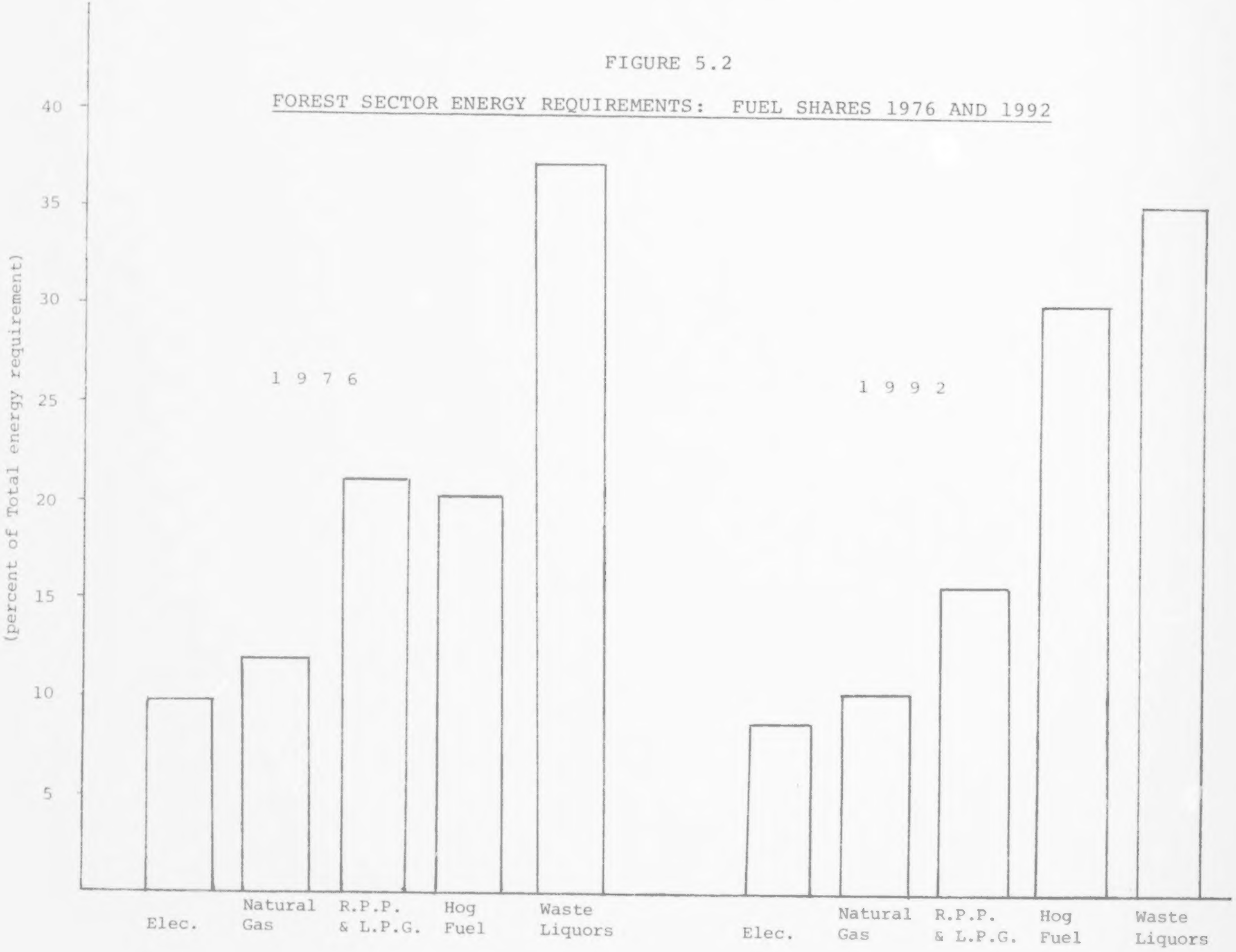
FIGURE 5.2

FOREST SECTOR ENERGY REQUIREMENTS: FUEL SHARES 1976 AND 1992



C. High Growth Forecast

The forecast presented in the preceding sections represents the Commission's "best estimate" forecast of production activity and energy requirements in the forest sector in British Columbia. For this forecast, it was assumed that the forest resource would be fully utilized by 1992. The assumed future annual growth in production activity was taken to be considerably lower than that actually experienced over the last decade. This outcome was principally attributable to such factors as increased competition in the world markets for forest products, and the increasing inaccessibility of the forest resource.

To test the impact on energy requirements, a higher growth forecast has been prepared assuming that after 1982, production in all forest industries will increase at rates equivalent to the 1966-1976 historical growth rates. Growth of this magnitude could arise from improved world markets for forest products and an enhanced competitive position of the producers in British Columbia.

Under this scenario, production of plywood and shingles and shakes (4.6 percent annual growth) and production of pulp (5.0 percent annual growth) will attain the maximum forecast levels by 1987. Lumber production, with an annual growth of 4 percent, will attain the forecast maximum output level by 1990. It is assumed that production in the logging industry will grow at the same rate as demand for wood input to the wood industries and the paper and allied industries. Based on these assumptions, growth in the logging industry will average 3.7 percent per year from 1982 to 1987, then fall off to 1.0 percent per year to 1992. All other factors--including lumber and plywood recovery factors, energy coefficients and fuel shares--are assumed to be the same as for the best estimate forecast.

Table 5.15 contains the forecast of production and total energy demand under the high growth assumption, by industry. Total energy requirements increase at an average annual rate of 4 percent from 1978 to 1987. By 1987, the industry has almost fully utilized the forest resource. As a result, growth in energy demand over the last five years of the forecast period is only .3 percent per annum.

Table 5.16 contains the forecast total energy requirements by fuel type. As in the best estimate forecast, black liquor and hog fuel increase their market shares at the expense of natural gas and R.P.P.'s over the forecast period. In this scenario, the increase is somewhat more rapid, and by 1987, over 64 percent of total energy demand in the forest sector is supplied by these two fuels.

TABLE 5.15

FORECAST ENERGY REQUIREMENTS - FOREST SECTOR
HIGH GROWTH SCENARIO
BY INDUSTRY

Industry		1978	1982	1987	1992
Logging:	production (000 m^3)	72,393	80,652	95,709	100,115
	energy (Quadrillion Joules)	12.705	14.154	16.800	17.570
Lumber:	production (000 m^3)	18,986	21,996	26,761	30,163
	energy (Quadrillion Joules)	30.435	35.270	42.900	48.350
Other Wood Products:	production (000 m^3)	2565	2889	3521	3521
	energy (Quadrillion Joules)	6.815	7.670	9.360	9.360
Market Pulp:	production (000 ADt)	3674	4176	4976	4976
	energy (Quadrillion Joules)	167.99	193.18	239.17	239.17
Paper and Paper Products:	production (000 t)	2171	2256	2982	2982
	energy (Quadrillion Joules)	50.15	53.92	75.69	75.69
Total Energy Requirement (Quadrillion Joules)		268.09	304.16	383.92	390.15

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TABLE 5.16

FORECAST ENERGY REQUIREMENTS - FOREST SECTOR HIGH GROWTH SCENARIO BY FUEL TYPE

(Quadrillion Joules)

	Natural Gas	R.P.P.	Electricity Purchased	Electricity Self-Gen. Hydro	L.P.G.	Hog Fuel	Waste Liquors	Total
1978	34.42	55.40	22.90	2.35	1.60	51.99	99.43	268.09
1982	42.63	56.15	25.95	2.35	1.76	62.89	112.43	304.16
1987	39.92	61.12	31.79	2.35	1.80	110.16	137.58	383.92
1992	40.43	61.12	32.46	2.35	2.06	115.40	137.58	390.15

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III. Minerals Sector

The minerals sector in British Columbia includes the mining, primary metals, and non-metallic minerals products industries. In 1976, the combined value of production of these industries amounted to approximately 2.15 billion dollars or just over 10 percent of total Gross Provincial Product. These industries also currently account for about 20 percent of total industrial energy requirements.

In the following sections each component industry of this sector is analyzed separately, and the results are summarized at the end of the discussion. Figure 5.3 summarizes the methodology employed in forecasting energy requirements in the minerals sector.

Mining

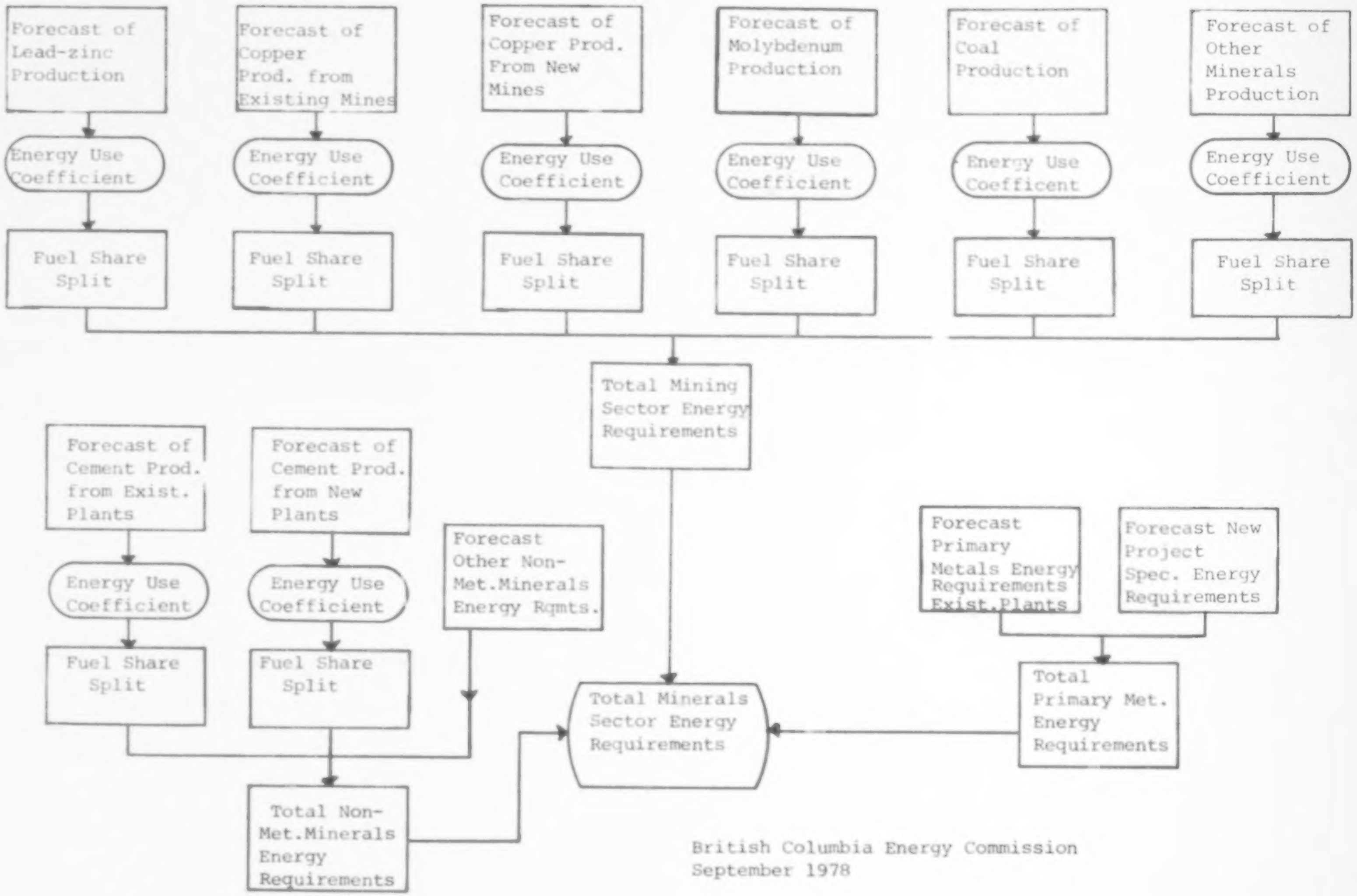
The mining sector includes metal mines, mineral fuels (coal), non-metallic mines and quarries.

Historical Production and Energy Use

In 1976, the value of British Columbia's mineral production was $1.5 billion (approximately 7 percent of total GPP). Although copper remains the major contributor to both value and volume of production, its relative importance is declining. In 1973 copper accounted for 53 percent of the total value of all mineral production in the province, but by 1976 this figure had fallen to only 24.9 percent. Coal, on the other hand, has increased from 8 percent of the total value of mineral production

FIGURE 5.3

MINERAL PRODUCTS SECTOR METHODOLOGY


Forecast of Lead-zinc Production
Energy Use Coefficient
Fuel Share Split
Forecast of Copper Prod. from Existing Mines
Energy Use Coefficient
Fuel Share Split
Forecast of Copper Prod. From New Mines
Energy Use Coefficient
Fuel Share Split
Forecast of Molybdenum Production
Energy Use Coefficient
Fuel Share Split
Forecast of Coal Production
Energy Use Coefficent
Fuel Share Split
Forecast of Other Minerals Production
Energy Use Coefficient
Fuel Share Split
Total Mining Sector Energy Requirements
Forecast of Cement Prod. from Exist. Plants
Energy Use Coefficient
Fuel Share Split
Forecast of Cement Prod. from New Plants
Energy Use Coefficient
Fuel Share Split
Forecast Other Non-Met.Minerals Energy Rqmts.
Total Non-Met.Minerals Energy Requirements
Total Minerals Sector Energy Requirements
Forecast Primary Metals Energy Requirements Exist.Plants
Forecast New Project Spec. Energy Requirements
Total Primary Met. Energy Requirements

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in 1973 to 19.6 percent in 1976. These two minerals alone accounted for over 65 percent of the energy used by the mining sector in 1975.

Ranking below copper and coal in value of production[17] in 1976 were molybdenum, zinc and lead which together contributed 12.7 percent, having increased from only 5 percent in 1974.

Table 5.17 shows a comparison of selected mineral production in British Columbia by volume and value, for the years 1972 to 1977. The locations of existing mines in the province are shown in Figure 5.4.

The energy consumption associated with the production of each mineral in British Columbia was estimated from Canadian data. Table 5.18 contains historical production figures for copper, molybdenum, lead-zinc, and coal, as well as estimates of the energy consumption associated with each and total energy consumption for the mining sector. The estimates of the energy associated with these minerals were derived from Statistics Canada data in the following manner. First, total energy consumption in Canadian mines that produce each particular type of mineral, was calculated.[18] This energy consumption was then divided by the total Canadian production of the related metals

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[17] Petroleum and natural gas production, though high in value, are relatively small energy users and have been excluded from the discussion.

[18] Statistics Canada Catalogues 26-201, 26-219, and 26-206 provided the data for these calculations.

TABLE 5.17

HISTORICAL MINERAL PRODUCTION BY VOLUME AND VALUE FOR SELECTED MINERALS 1972 - 1977

	1972	1973	1974	1975	1976	1977*
Copper kg	211,790,275	324,093,297	287,489,993	258,497,599	263,618,197	291,754,973
($)	(209,403,822)	(594,830,904)	(541,644,913)	(331,693,850)	(378,984,941)	(397,245,195)
Gold kg	3,467	5,380	4,599	4,819	5,419	6,070
($)	(7,022,353)	(18,428,792)	(26,981,595)	(25,082,494)	(21,877,115)	(30,220,883)
Iron Concentrates t	1,139,597	1,423,160	1,306,815	1,299,215	1,255,277	509,297
($)	(11,642,379)	(12,906,063)	(12,742,227)	(15,245,902)	(14,760,526)	(8,558,000)
Lead kg	88,092,180	84,659,678	55,241,729	70,603,483	85,407,582	79,876,425
($)	(28,896,566)	(30,400,945)	(23,333,016)	(24,450,158)	(32,796,533)	(42,908,188)
Molybdenum kg	12,716,876	13,782,286	13,798,289	13,026,627	14,088,686	15,382,291
($)	(43,260,349)	(52,260,232)	(60,716,942)	(71,201,391)	(94,109,139)	(137,638,367)
Silver kg	196,310	217,723	165,577	196,306	239,721	247,038
($)	(11,519,660)	(19,712,301)	(28,440,365)	(30,545,947)	(32,532,836)	(38,559,692)
Zinc kg	121,695,816	137,353,509	77,718,308	99,668,230	106,498,987	110,742,319
($)	(47,172,894)	(62,564,751)	(59,582,753)	(80,572,872)	(65,499,108)	(65,681,248)
Asbestos t	95,977	98,843	83,395	76,771	70,433	96,241
($)	(20,870,241)	(21,102,892)	(27,298,900)	(37,849,743)	(40,727,296)	(59,940,244)
Sulphur t	270,050	296,675	206,627	246,079	231,704	283,306
($)	(2,306,933)	(4,187,387)	(3,068,507)	(5,738,134)	(4,296,189)	(4,029,180)
Coal t	5,466,364	6,924,122	7,756,756	8,924,816	7,537,695	8,655,808
($)	(66,030,210)	(87,976,105)	(154,593,643)	(317,111,741)	(298,683,679)	(371,588,709)
All Minerals ($)	(636,217,776)	(1,113,580,034)	(1,197,438,526)	(1,364,049,199)	(1,520,263,436)	(1,836,558,373)

* Estimate

Source: Ministry of Mines and Petroleum Resources, Press Releases.

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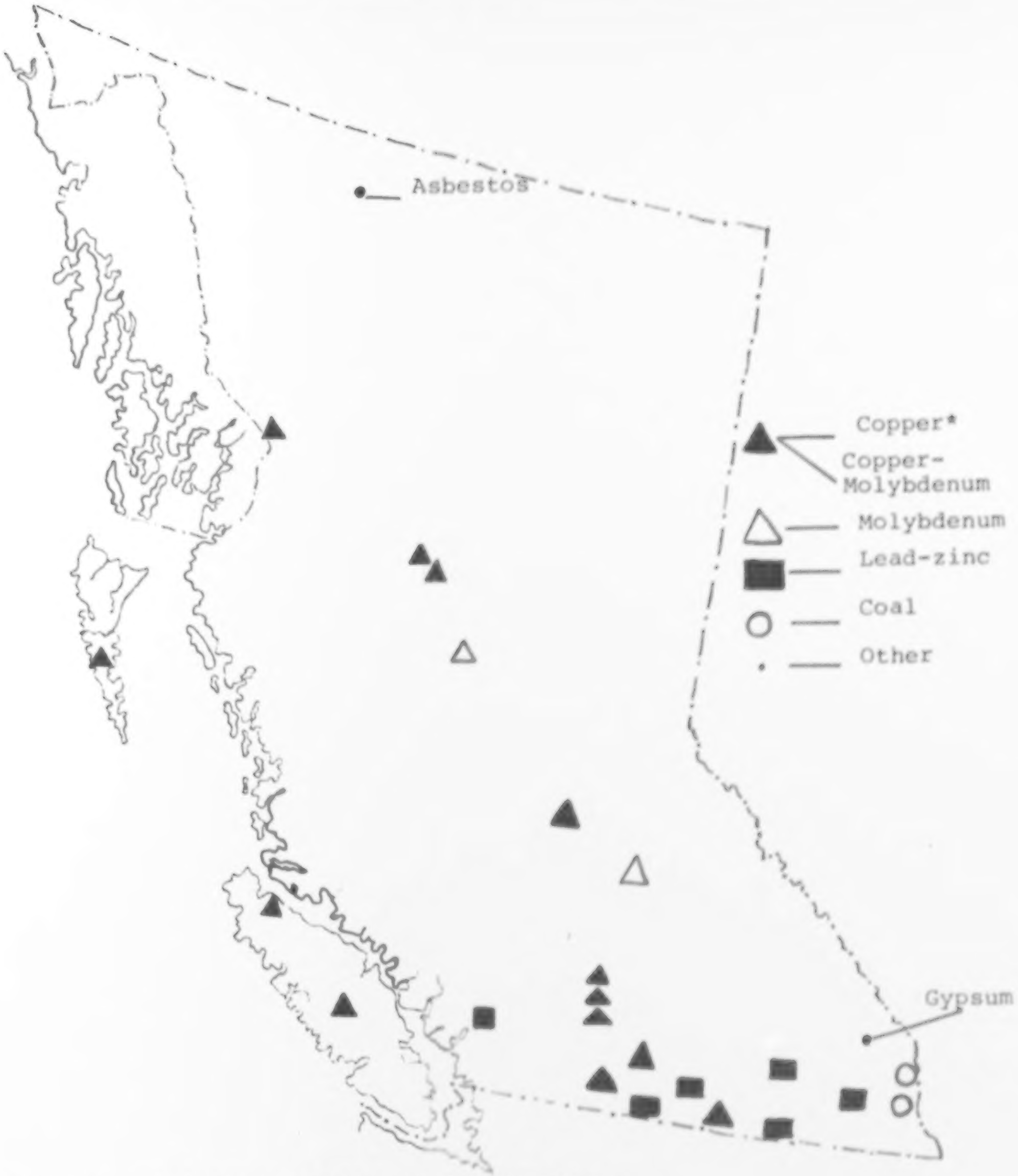
FIGURE 5.4

PRINCIPAL MINES IN BRITISH COLUMBIA


Asbestos
Copper*
Copper-
Molybdenum
Molybdenum
Lead-zinc
Coal
Other
Gypsum

Source: Ministry of Economic Development,
The Manual of Resources.

TABLE 5.18

HISTORICAL PRODUCTION OF SELECTED MINERALS AND THE ESTIMATED ENERGY CONSUMPTION ATTRIBUTABLE TO EACH, B.C.

	Copper		Molybdenum		Lead-Zinc		Coal		Other	Total
	(kg)	Quadrillion Joules	(kg)	Quadrillion Joules	(kg)	Quadrillion Joules	(t)	Quadrillion Joules	Quadrillion Joules	
1970	96,001,731	2.399	14,187,019	1.426	222,458,720	0.844	3,159,486	1.777	2.909	9.356
1971	127,288,846	3.529	9,926,913	0.998	251,012,680	0.962	4,206,233	2.130	4.093	11.712
1972	211,836,958	6.494	12,719,671	1.279	210,242,320	0.968	5,938,873	3.534	5.395	17.640
1973	317,610,057	9.615	13,785,568	1.386	222,276,590	1.038	7,050,767	4.195	4.870	21.104
1974	287,553,387	9.111	13,790,129	1.386	132,989,360	0.603	7,739,377	4.605	4.342	20.047
1975	258,497,599	8.757	13,026,627	1.309	170,271,713	0.817	8,924,816	4.659	4.664	20.206
1976[1]	263,618,297		14,088,686		191,906,569		7,537,695			
1977[1]	291,754,973		15,382,291		190,618,744		8,655,808			

Source: Production figures from Ministry of Mines and Petroleum Resources, Press Releases.
Energy consumption figures estimated as described in the text.

[1] Data on energy consumption in the mining industry is not yet available for 1976 and 1977.

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to yield an energy coefficient.[19] The coefficient was then applied to British Columbia's historical production. Only three years data were available for molybdenum mines, thus the energy coefficients from these three years were averaged and this average was applied to production over the historical period.

The coefficients obtained from these calculations coincide quite closely with coefficients estimated from information received from operating mines in British Columbia. The latter coefficients were estimated on the basis of information obtained from a number of individual mines and could not be assumed to be representative of all mines, though they compare quite well with Canadian data. For this reason, they were not used as the basis of the estimates. The energy coefficient for coal production in British Columbia was increased by an average of 50 percent over the average Canadian coefficient to reflect the higher energy use per tonne of coal produced in this province.[20]

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[19] *To obtain the energy coefficient for copper, for example, energy consumption of copper/gold/silver; gold, and nickel/copper mines are calculated. Then this consumption was divided by total production of these minerals to arrive at the energy coefficient.*

[20] *According to Statistics Canada information, B.C. coal mines use approximately 50 percent more dollars of fuel and electricity per tonne of coal mined than do all Canadian mines. Most of the coal mined in B.C. is metallurgical coal which requires more energy for drying purposes as opposed to the rest of Canada,where there is more thermal coal mined.*

Future Production Levels

British Columbia contains approximately thirty major known but undeveloped deposits of copper, molybdenum, lead, zinc, and coal as shown in Figure 5.5. Many of these mines are expected to become producing mines over the next twenty-five years. The future rate of development of these deposits and exploration for new deposits will depend on how the mining companies view the future of the industry, especially with regard to government taxation policies. It is assumed that government policies will be such that development is encouraged over the forecast period.

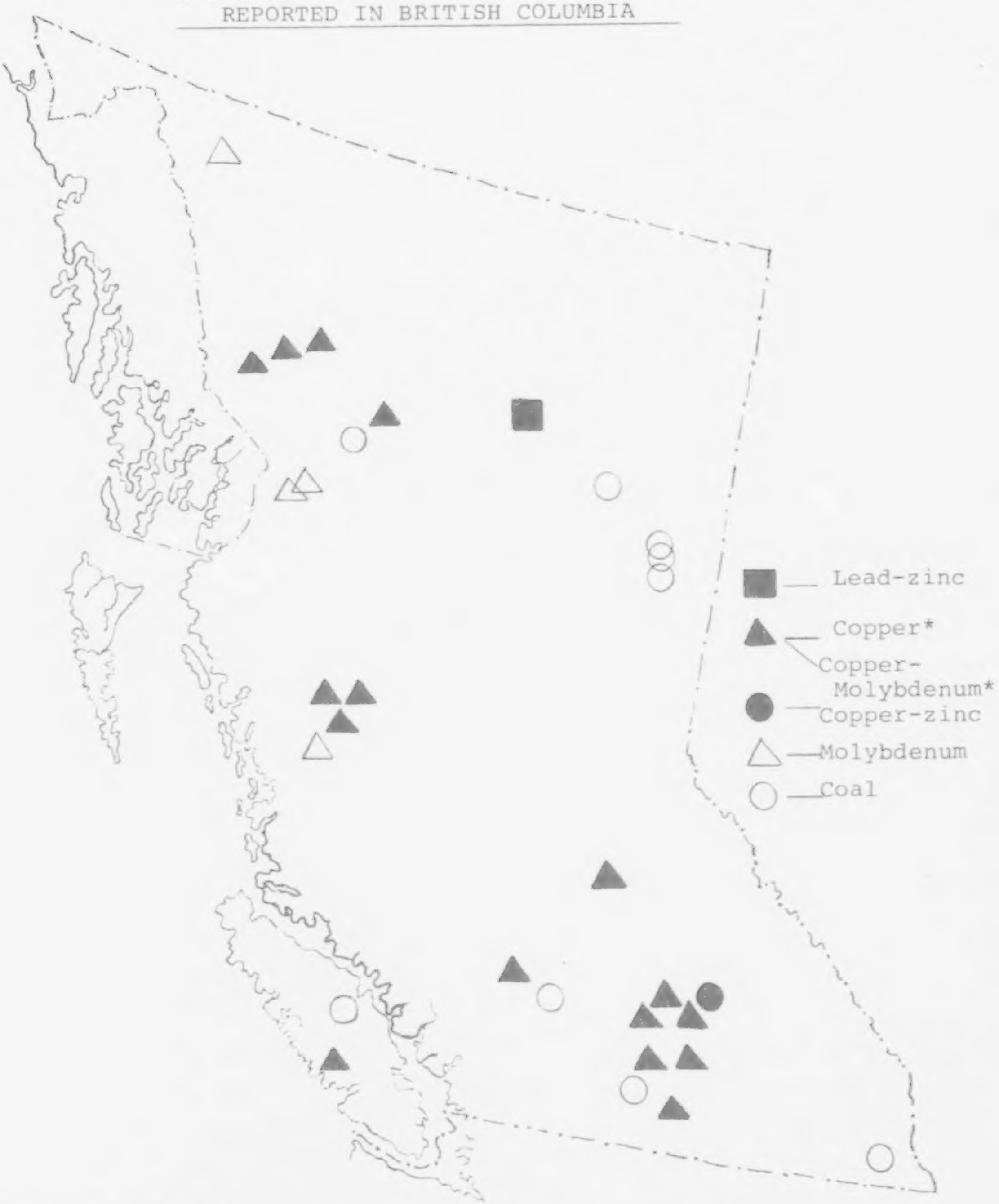
To test the impact on energy requirements, two forecasts of future mining activity were made. Sections A to F deal with the best estimate forecast and Section G deals with the high forecast.

A. Lead-Zinc

Production of lead and zinc appears to have stabilized in recent years at just under 200 thousand tonnes per year with no new major developments appearing imminent at this time, in light of existing markets for these metals. There is potential, however, for a small silver/lead/zinc mine in the northern area of the province by 1981. Therefore, for the purpose of the forecast, it was assumed that production

FIGURE 5.5

MAJOR UNDEVELOPED MINERAL DEPOSITS REPORTED IN BRITISH COLUMBIA


Lead-zinc
Copper*
Copper-Molybdenum*
Copper-zinc
Molybdenum
Coal

Source: The Vancouver Province: Mining B.C. Series

* Also contains deposits of other metals such as iron, precious metals, etc.

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will stay constant at the 1977 level of 190 thousand tonnes per year to 1980, after which annual production will increase to 205 thousand tonnes for the remainder of the forecast period.

B. Copper

Copper is the leading mineral in the British Columbia mining industry and has historically topped all other minerals in total value of production. There are currently fourteen producing mines in the province with a combined measured and indicated reserve of 5.5 million tonnes of copper.

The copper production forecast is shown in Table 5.19. The figures in the table include estimates of production from both existing mines and potential producers.[21] Future production from existing mines is based on current production rates and on current reserve estimates. The forecast of production from new mines is based on a subjective evaluation of the probable rate of development of known mineral deposits. The precise timing of the development of new mines will depend critically on the future economic climate of the industry. This forecast assumes that while two to three new small mines will come into production during the 1980-1982 period, development of

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[21] *The information on which this forecast is based was obtained from the B.C. Ministry of Mines and Petroleum Resources. Much of the information is very speculative and thus the resulting forecast is only one "reasonable" estimate of the future of the copper mining industry in British Columbia.*

TABLE 5.19

PROJECTION OF COPPER AND MOLYBDENUM PRODUCTION FOR BRITISH COLUMBIA

(tonnes)

	Copper			
	Existing Mines	New Mines	Total	Molybdenum
1976*	263,618	-	263,618	14,089
1977*	291,755	-	291,755	15,382
1978	348,750	-	348,750	18,090
1979	313,850	-	313,850	18,090
1980	250,100	22,450	272,550	24,090
1981	250,100	39,950	290,050	24,990
1982	250,100	67,350	317,450	24,990
1987	217,000	171,900	389,000	34,340
1992	182,900	292,200	475,100	37,460

* Actual

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major new deposits such as Valley Copper and Berg will occur only after 1982. The depressed state of the copper industry in 1978, arising from low international prices on the London Metal Exchange, precludes development of these large deposits on a short term basis.

C. Molybdenum

British Columbia currently accounts for over fifty percent of the molybdenum produced in Canada, and is an important supplier to the industrial economies of Japan and Western Europe. Unlike copper, the market for molybdenum has been marked by steady supply and stable prices. The size of the market has increased rapidly over the past decade as new applications have expanded the metal's usefulness. It is expected that the growth in the molybdenum market will continue during the forecast period.

The forecast of molybdenum production is shown in Table 5.19. This forecast was developed in the same fashion as the forecast for copper and the same uncertainties concerning the timing and size of future developments apply.

Based upon discussions with industry sources, it is predicted that the production of molybdenum will increase rapidly over the forecast period with average annual rates of growth in excess of 6 percent.

D. Coal

Coal mining in British Columbia has experienced renewed growth since the late 1960's. Over the period 1969-1977, coal production increased at an average annual rate of 34 percent. This tremendous growth in coal mining was a direct result of increasing world demand for coking coal which provided the impetus for developing new resources and increasing production from existing mines. As prices of both refined petroleum products and natural gas increase, and with the prospect that worldwide shortages of both fuels could occur by the end of the century, coal's future appears secure--not only as a raw material in steel manufacture, but also as a source of thermal energy.

Despite long term opportunities for export and domestic use of coal, market conditions do not appear suitable for rapid development of British Columbia coal resources in the short term. The sluggish world economy for example, idled approximately 35 percent of steel capacity in Japan in 1977, the destination of almost all metallurgical coal exported from the province.[22] The Japanese steel industry is expected to regain its competitive position and increase production by the mid 1980's, resulting in rapidly increasing demand for metallurgical coal from 1982 to 1987. In later years demand is forecast to increase at a much slower rate, in line with the cyclical nature of the industry.

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[22] *Dames and Moore, A Report on the Current Status of the Canadian Coal Mining Industry, May 1978.*

The forecasts of coal production shown in Table 5.20 have been prepared with the advice of the Ministry of Economic Development, based upon the above market outlook and an assessment of prospects for both expansion of existing mines in the West Kootenays and development of new mines. Some of the possibilities allowed for include the development of the metallurgical coal deposits in the northeast region, and development of a thermal coal mine on Vancouver Island near Quinsam Lake. Since it is uncertain whether or when the development of coal by B.C. Hydro for thermal generation of electricity may occur, no provision has been made for the mining energy requirements of such projects. If, for instance, the Hat Creek development was to take place, the electricity requirement of the project would simply be treated as a reduction in the output capability of the plant.

E. Other Minerals

This sector includes miscellaneous metals such as gold, silver, and iron; industrial minerals such as asbestos and sulphur; sand and other structural materials; and petroleum and natural gas. Projecting future production levels would be meaningless for the purposes of this forecast.

TABLE 5.20

POTENTIAL CLEAN COAL AVAILABILITY FROM B.C.

(millions of tonnes)

	Metallurgical Coal	Oxidized Metallurgical and Low Rank Thermal Coal[1]	Total
1976*	6.31	0.68	7.54
1977*	7.86	0.73	8.58
1978	8.10	1.00	9.10
1979	8.34	1.22	9.56
1980	8.55	1.48	10.03
1981	8.72	1.81	10.53
1982	8.86	2.20	11.06
1987	14.33	3.48	17.81
1992	15.15	5.50	20.65

* Actual production

[1] Does not include coal for thermal generation of electricity.

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Therefore, no projection of other minerals has been attempted and their energy requirements alone are discussed in a succeeding section.

Future Energy Requirements

A. Lead-zinc

Although the production of lead and zinc is forecast to remain relatively stable, this does not necessarily apply to the energy requirements forecast. More stringent environmental requirements, a shift of fuel types, or the maintenance of production levels through the mining of lower grade ore could result in higher per unit energy requirements.

For the purposes of this forecast, the average Canada wide energy coefficient of 4.6 GJ/t for 1972-1974 was utilized for the 1976-1982 period; thereafter an energy coefficient of 4.8 GJ/t was assumed.

Lead-zinc operations are characterized by the extensive use of electricity. In 1973,[23] fuel shares in this sector of the mining industry for Canada were as follows:

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[23] *Since 1974 was a poor year for the lead-zinc mining industry due to labour-management strife, 1973 data has been used to illustrate fuel shares in this sector of the mining industry.*

Electricity	53.2 percent
R.P.P.	33.5 percent
Coal	7.3 percent
Natural gas	3.6 percent
L.P.G.	2.4 percent

In British Columbia, however, fuel shares in lead-zinc mining are significantly different. The following fuel shares in British Columbia were estimated from information received from the industry for the period 1973 to 1975:

Electricity	59.4 percent
R.P.P.	2.9 percent
Coal	-
Natural gas	37.5 percent
L.P.G.	.3 percent

The greater share of electricity in this province relative to the country as a whole can be attributed to the fact that the province's largest producer of lead and zinc, Cominco Limited, has its own generating facilities. The predominant utilization of electricity is expected to prevail in the future.

The greater use of natural gas in British Columbia arises from the proximity of major lead-zinc mines in the province to natural gas transmission/distribution systems.

It is considered unlikely that any significant displacement of gas by oil will take place. In this forecast it is assumed that fuel shares will remain constant over the forecast period.

The energy requirements forecast for lead-zinc mining in British Columbia is shown in Table 5.21.

B. Copper

The current energy requirement for British Columbia copper mines is estimated to be approximately 33.8 GJ per tonne of copper.[24] As in the case of lead-zinc mines, the future energy coefficient will be affected by a variety of factors.

At the present time, copper ore mined in this province has an average copper content of 0.66 percent. According to the Report of the British Columbia Copper Task Force, mines which will be coming into production in the next decade will have a copper content which is on the average less than current content levels. To account for this factor, it is assumed that energy requirements per tonne of copper for new mines will be 5 percent higher to 1982 and another 5 percent higher by 1987. For existing mines, the energy coefficient is held constant at the current level of 33.8 GJ per tonne.

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[24] *See Table 5.18, 1975.*

TABLE 5.21

FORECAST ENERGY CONSUMPTION IN THE LEAD-ZINC MINING INDUSTRY

	Lead-Zinc Production	Electricity	Natural Gas	R.P.P.	L.P.G.	Total
			Energy Consumption			
	('000 tonnes)		(Quadrillion Joules)			
1976	192	0.524	0.331	0.026	0.002	0.883
1977	191	0.521	0.330	0.026	0.002	0.879
1978	190	0.519	0.328	0.025	0.002	0.874
1979	190	0.519	0.328	0.025	0.002	0.874
1980	190	0.519	0.328	0.025	0.002	0.874
1981	205	0.560	0.354	0.027	0.002	0.943
1982	205	0.560	0.354	0.027	0.002	0.943
1987	205	0.588	0.371	0.029	0.003	0.991
1992	205	0.588	0.371	0.029	0.003	0.991

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Fuel share in the British Columbia copper mining industry as estimated from information received from the industry are as follows:

Electricity	53.1 percent
R.P.P.	43.6 percent
Natural gas	1.0 percent
L.P.G.	2.3 percent
	100.0 percent

It appears that new mines will use a larger share of electricity in place of petroleum products than existing mines. The shares of natural gas and L.P.G., however, are not expected to change. Energy requirements for new mines have thus been split by fuel type as follows:

Electricity	60.0 percent
R.P.P.	36.7 percent
Natural gas	1.0 percent
L.P.G.	2.3 percent

Fuel shares in existing mines are held constant through to 1992. Forecast energy consumption for copper mines is shown in Tables 5.22, 5.23, and 5.24.

C. Molybdenum

The current energy usage in molybdenum mines is estimated to be 100.5 GJ per tonne of molybdenum.[25] This coefficient is held constant over the forecast period since

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[25] *See Table 5.18.*

TABLE 5.22

FORECAST ENERGY CONSUMPTION IN THE COPPER MINING INDUSTRY
(Existing Mines)

	Production	Total Energy	Electricity Purch.	Electricity Self-Generated Hydro	R.P.P.	Natural Gas	L.P.G.
	(tonnes)		(Quadrillion Joules)				
1976	263,618	8.910	4.671	0.060	3.385	.089	.205
1977	291,755	9.861	5.176	0.060	4.299	.099	.227
1978	348,750	11.788	6.199	0.060	5.140	.118	.271
1979	313,850	10.608	5.573	0.060	4.625	.106	.244
1980	250,100	8.453	4.429	0.060	3.686	.085	.194
1981	250,100	8.453	4.429	0.060	3.686	.085	.194
1982	250,100	8.453	4.429	0.060	3.686	.085	.194
1987	217,100	7.338	3.897	-	3.199	.073	.169
1992	182,900	6.180	3.280	-	2.690	.060	.140

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TABLE 5.23

FORECAST ENERGY CONSUMPTION IN THE COPPER MINING INDUSTRY

(New Mines)

	Production	Total Energy	60% Purchased Electricity	36.7% R.P.P.	1% Natural Gas	2.3% L.P.G.
	(tonnes)	(Quadrillion Joules)				
1976	-	-	-	-	-	-
1977	-	-	-	-	-	-
1978	-	-	-	-	-	-
1979	-	-	-	-	-	-
1980	22450	.797	.478	.292	.008	.018
1981	39950	1.418	.851	.520	.014	.033
1982	67350	2.390	1.434	.877	.024	.055
1987	171,900	6.406	3.844	2.351	.064	.147
1992	292,200	10.889	6.533	3.996	.109	.250

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TABLE 5.24

FORECAST ENERGY CONSUMPTION IN THE COPPER MINING INDUSTRY

(All Mines)

(Quadrillion Joules)

	Production	Total Energy	Electricity Purch.	Self Generated Hydro	R.P.P.	Natural Gas	L.P.G.
	(tonnes)	(Quadrillion Joules)					
1976	263,618	8.910	4.671	0.060	3.885	.089	.205
1977	291,755	9.861	5.176	0.060	4.299	.099	.227
1978	348,750	11.788	6.199	0.060	5.140	.118	.271
1979	313,850	10.608	5.573	0.060	4.625	.106	.244
1980	272,550	9.250	4.907	0.060	3.978	.093	.213
1981	290,050	9.871	5.280	0.060	4.206	.099	.227
1982	317,450	10.844	5.863	0.060	4.563	.108	.249
1987	389,000	13.744	7.741	-	5.550	.137	.316
1992	475,100	17.069	9.813	-	6.686	.169	.390

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the new deposits of molybdenum expected to be developed have an ore grade similar to those already being exploited. Fuel distribution in this sector is currently estimated to be as follows:

Electricity	68.1 percent
R.P.P.	20.2 percent
Natural gas	11.5 percent
L.P.G.	.2 percent
	100.0 percent

This fuel split is held constant over the forecast period. The forecast of energy requirements for molybdenum mines is shown in Table 5.25.

D. Coal

On the basis of discussions with the industry and from industry reports, it was estimated that British Columbia metallurgical coal mines currently consume approximately 554 million joules per tonne of clean product coal produced. It is likely that this level of energy use will not increase significantly and this figure is assumed to hold over the forecast period. For thermal coal production, the energy coefficient was estimated by removing the natural gas component from the above figure, since thermal coal does not generally require drying.

TABLE 5.25

FORECAST ENERGY CONSUMPTION IN THE MOLYBDENUM MINING INDUSTRY

(Quadrillion Joules)

	Production (tonnes)	Total Energy	Electricity	R.P.P.	Natural Gas	L.P.G.
1976	14,089	1.416	.964	.286	.163	.003
1977	15,382	1.546	1.053	.312	.178	.003
1978	18,090	1.818	1.238	.367	.209	.004
1979	18,090	1.818	1.238	.367	.209	.004
1980	24,090	2.421	1.649	.489	.278	.005
1981	24,990	2.512	1.710	.507	.289	.005
1982	24,990	2.512	1.710	.507	.289	.005
1987	34,340	3.451	2.350	.697	.397	.007
1992	37,460	3.765	2.564	.761	.433	.008

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Fuel shares in the coal mining industry are currently estimated to be as follows:

Electricity	16.9 percent
Natural gas	52.0 percent
R.P.P.	31.1 percent

There does not appear to be much scope for inter-fuel substitution between the three fuels listed above. Extensive use is made of diesel and electricity by the customary truck-and-shovel mining method, with natural gas used primarily for coal drying. Fuel shares are therefore held constant over the forecast period. The forecast of energy consumption in British Columbia coal mines is shown in Table 5.26.

E. Other Minerals

As indicated previously, a forecast of other minerals production was not attempted. Energy usage by this group of mines has therefore been treated as a residual. Since 1969 the percentage of total energy used by the mining sector in the production of other minerals has fallen (see Table 5.18). In 1969, other minerals accounted for over 32 percent of the energy consumed by the mining industry, but by 1975 this percentage had fallen to just over 23 percent. For the purposes of forecasting energy requirements, it was assumed that this share would continue to decline, particularly with the closure of the Texada iron mine in late 1976. For the period 1977 to 1992, it was assumed that energy consumed in production of other minerals would be equivalent to 20 percent of energy consumed in the remainder of the mining industry.

TABLE 5.26

FORECAST ENERGY CONSUMPTION IN THE COAL MINING INDUSTRY

(Quadrillion Joules)

	Production (10⁶ tonnes)	Total Energy	Natural Gas	R.P.P.	Electricity
1977	7.86[1] .73	4.354 .194	2.264 -	1.354 .126	.736 .068
1978	8.10 1.0	4.487 .266	2.333 -	1.395 .173	.758 .093
1979	8.34 1.22	4.620 .324	2.402 -	1.437 .211	.781 .113
1980	8.55 1.48	4.737 .394	2.463 -	1.473 .256	.801 .138
1981	8.72 1.81	4.831 .481	2.512 -	1.502 .313	.816 .168
1982	8.86 2.2	4.908 .585	2.552 -	1.526 .380	.829 .205
1987	14.33 3.48	7.939 .925	4.128 -	2.469 .601	1.342 .324
1992	15.15 5.50	8.393 1.463	4.364 -	2.610 .951	1.418 .512

[1] Vertical pairs refer to: Metallurgical coal
Thermal coal

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The current fuel split in the other minerals sector was estimated for each fuel type by subtracting the estimated fuel usage by copper mines, lead-zinc mines, molybdenum mines and coal mines from total fuel consumption in the British Columbia mining industry as reported in Statistics Canada Catalogue 26-201. The resulting distribution is as follows:

Electricity	28.7 percent
R.P.P.	50.0 percent
Natural gas	20.0 percent
L.P.G.	1.1 percent
Coal	.2 percent

As in the case of the preceding mining categories, the existing fuel split was held constant over the forecast period. The forecast of energy usage in the other minerals sector of the mining industry is shown in Table 5.27.

F. Mining Sector Total Energy Requirements

Table 5.28 contains the aggregate best estimate forecast of energy requirements for the mining sector of the province. Total energy is forecast to grow at an average annual compound rate of 5.7 percent over the period 1977 to 1992.

TABLE 5.27

FORECAST ENERGY CONSUMPTION IN OTHER MINING INDUSTRIES

(Quadrillion Joules)

	Total Energy	Electricity	Natural Gas	R.P.P.	L.P.G.	Coal
1977	3.367	.966	.673	1.684	.037	.007
1978	3.847	1.104	.769	1.924	.042	.008
1979	3.649	1.047	.730	1.825	.040	.007
1980	3.535	1.015	.707	1.768	.039	.007
1981	3.728	1.070	.746	1.864	.041	.007
1982	3.958	1.136	.792	1.979	.044	.008
1987	5.392	1.548	1.078	2.696	.059	.011
1992	6.336	1.818	1.267	3.168	.070	.013

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TABLE 5.28

FORECAST ENERGY REQUIREMENTS
TOTAL MINING SECTOR

(Quadrillion Joules)
(Best Estimate)

	Electricity	Natural Gas	R.P.P.	L.P.G.	Coal	Total
1977	8.580	3.544	7.801	.269	.007	20.201
1978	9.971	3.757	9.024	.319	.008	23.079
1979	9.331	3.775	8.490	.290	.007	21.893
1980	9.089	3.869	7.989	.259	.007	21.211
1981	9.664	4.000	8.419	.275	.007	22.366
1982	10.363	4.095	8.982	.300	.008	23.750
1987	13.893	6.111	12.042	.385	.011	32.352
1992	16.713	6.604	14.205	.471	.013	38.017

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G. High Growth Mining Forecast

Under the high growth assumption, production in the mining sector grows more rapidly after 1982 than in best estimate forecast presented in the preceding sections. The higher growth rates could arise from exceptionally strong world demand for minerals produced in British Columbia, in combination with significant discoveries of new ore reserves in the province to support the expanded production.

For copper and molybdenum mining it is assumed that after 1982 new mines will develop more rapidly than forecast in sections B and C. Growth in production of these two metals is forecast to average 5.5 and 8.1 percent respectively per year from 1982 to 1992, reflecting this increased development. No improvement is assumed for lead-zinc mining under the high growth scenario.

The production of metallurgical coal is increased for the 1987 to 1992 period to reflect the possible continuation of the high growth in demand for this commodity forecast for 1982 to 1987. Per unit energy requirements for all mining activity and the fuel shares were kept the same as in the best estimate forecast.

Energy requirements for the other mining sector were calculated as a residual. For 1987 and 1992, it was assumed that this sector would continue to maintain its share at 20 percent of energy requirements in the remainder of the mining industry.

Tables 5.29 and 5.30 contain the forecast of mining sector energy requirements under the high growth assumptions by industry and by fuel type respectively. Total mining energy requirements under this scenario grow at an average compound rate of 6.0 percent per annum from 1977 to 1992.

Non-Metallic Mineral Products Industries

The industries of the non-metallic mineral products group that are of significance in British Columbia are cement manufacture, which accounted for 67 percent of energy consumption in the industry in 1975, glass manufacture with 10 percent, ready-mix concrete with 7 percent, clay products with 6 percent and concrete products with 3 percent. The historical energy consumption of this group of industries is shown in Table 5.31. The ten year average annual compound growth rate was 8.2 percent to 1975.

TABLE 5.29

MINING SECTOR ENERGY REQUIREMENT BY INDUSTRY
HIGH GROWTH FORECAST

		1977	1982	1987	1992
Lead-zinc:	production	191,000	205,000	205,000	205,000
	energy	.879	.943	.991	.991
Copper:	production	291,755	317,450	403,100	543,000
	energy	9.860	10.844	14.270	19,590
Molybdenum:	production	15,382	24,990	39,340	54,660
	energy	1.546	2.512	3.950	5.490
Coal:	production	8,590,000	11,060,000	17,810,000	28,579,000
	energy	4.548	5.493	8.864	14.249
Other Minerals:	energy	3.367	3.958	5.615	8.066
Total Mining:	energy	20.201	23.750	33.690	48.385

NOTE: Production figures are tonnes;
Energy figures are quadrillion joules.

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TABLE 5.30

MINING SECTOR ENERGY REQUIREMENTS BY FUEL TYPE
HIGH GROWTH FORECAST

(Quadrillion Joules)

	Electricity	Natural Gas	R.P.P.	L.P.G.	Coal	Total
1977	8.580	3.544	7.801	.269	.007	20.201
1982	10.363	4.095	8.982	.300	.008	23.750
1987	14.617	6.221	12.448	.402	.011	33.699
1992	21.048	9.442	17.350	.526	.016	48.385

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TABLE 5.31

HISTORICAL ENERGY REQUIREMENTS NON-METALLIC MINERALS

(Quadrillion Joules)

	Gasoline	Fuel Oil	L.P.G.	Natural Gas	Electricity	Total
1965	.190	1.920	.009	2.595	.327	5.041
1966	.211	2.775	.013	2.321	.390	5.710
1967	.243	2.775	.015	2.733	.443	5.742
1968	.200	2.406	.017	2.585	.422	5.630
1969	.200	2.785	.028	3.313	.528	6.854
1970	.211	2.500	.028	3.862	.528	7.129
1971	.274	3.429	.049	4.516	.654	8.922
1972	.285	3.087	.103	4.284	.707	8.460
1973	.295	4.125	.069	4.779	.833	10.101
1974	.274	3.978	.074	5.507	.728	10.561
1975*	.240	4.449	.060	5.524	.802	11.075

Source: Statistics Canada, Fuel & Electricity Purchased and Consumed by Manufacturing Industries Catalogue 57-002. Statistics Canada, 57-208.

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The Cement Industry

Cement production in British Columbia is controlled by two companies which together operate three plants. All three plants, including the new plant recently opened on Tilbury Island, use natural gas as their major process fuel. The latter plant replaces an older, smaller plant at Bamberton on Vancouver Island, which used fuel oil for this purpose. Total provincial cement capacity is now 1,735,000 tonnes per year, up from 1,275,000 tonnes per year when the Bamberton plant was operating. Cement productions of the three plants in 1976 was approximately 846,549 tonnes.[1]

The two plants at Kamloops and Richmond currently utilize the older wet process technology, or an improvement on this, a dry process without a preheating tower. The plant at Tilbury Island uses a dry process with a four-stage preheating system. This process has much lower requirements for process heat but marginally higher electricity requirements than the wet process. Therefore, with the opening of this plant, the average energy coefficient per tonne of production will decline significantly, relative to average energy use when the Bamberton plant was in operation.

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[1] *Ministry of Mines and Petroleum Resources press release, December 8, 1977.*

Total energy requirements, however, will be higher due to the expected large increase in annual production. Future cement production in British Columbia is forecast to increase gradually to 1992 with only small additions to existing capacity expected over the forecast period. Production at this level will result in a surplus of cement over domestic requirements. There exists, however, a minor but long-standing export market in the Pacific Northwest area that can be expected to continue. There is also a shorter-run demand for export to the United States caused by widespread plant obsolescence and by under-estimation of demand growth. Also, to the extent that capacity exists, the cost advantages of the dry process plant will allow exports for some time to come. Any decline in export demand due to improved production conditions in the United States is assumed to be offset by increases in domestic demand, as population and construction activity increase.

Technological advances in cement manufacturing tend to counter each other in energy use per unit of output. Gains in energy efficiency are obtained through:

a) reuse of waste heat
b) economies of scale
c) advances in process control
d) adoption of dry process technology.

These developments have been partly countered by the greater per unit energy requirements of increased mechanization, of finer grinding and of pollution control equipment. On balance, per unit energy use can be expected to decline only as plant capacity utilizing the dry process comes on line. Accordingly, two sets of energy coefficients have been used, those for existing plants which continue to use the older, more energy intensive processes, and those for new or converted dry process plants. On the basis of information received from the industry, only the Richmond plant was assumed to convert to the dry process by the end of the forecast period.

Table 5.32 contains the forecast energy requirements for the cement industry. The forecast of natural gas and fuel oil requirements was obtained from the industry.[28] The forecast of electricity requirements was estimated on the basis of these fuel requirements and an estimate of the fuel/electricity ratio for each type of cement manufacture process.

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[28] *Both Inland Cement Industries Ltd. and Canada Cement Lafarge Limited submitted forecasts of fuel requirements to the Commission's 1978 Natural Gas Field Price Hearing.*

TABLE 5.32

FORECAST ENERGY REQUIREMENTS
CEMENT MANUFACTURERS

(Quadrillion Joules)

	Natural Gas	R.P.P.	Electricity	Total
1977	5.900	3.310	.645	9.855
1978	7.366	1.660	.705	9.731
1979	7.366	.223	.686	8.275
1980	7.406	.226	.691	8.323
1981	7.522	.235	.706	8.463
1982	7.562	.238	.711	8.511
1987	7.170	.237	.682	8.089
1992	8.226	.237	.741	9.204

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Other Non-Metallic Mineral Products Industries

Growth potential in industries other than cement is mixed. The glass and glass products industry has had considerable excess capacity since the elimination of disposable glass bottles and the closing of the B.C. Distillers operation. Therefore, no expansion in bottle and glass container manufacturing plants is assumed in this forecast. All provincial demands for plate glass, window glass and other glass products are at present met by imports. Labour costs, energy costs and market size do not favour the establishment of manufacturing facilities for these products. The remaining activities in the industry in British Columbia include miscellaneous glass shaping and glass product fabricating.

Some industries, such as ready-mix concrete, appear to be almost wholly supplying the requirements of the provincial market. These industries can reasonably be expected to grow at the same rate as that of the population, as can the clay products industry. Concrete products industries, including manufacture of concrete pipe and structural concrete, on the other hand, are not meeting provincial requirements and consequently the growth potential in these industries is high. Miscellaneous non-metallic mineral industries also enjoy a high growth potential.

The average energy requirement for these industries is forecast to increase at the same annual rate as growth in GPP. This will allow for faster growth in the higher potential industries and for slow growth in the remaining industries such as glass bottle manufacture. It is expected that electricity will increase its share of the market with the advent of new technologies in some industries. The forecast combined with that for the cement manufacturing industry is contained in Table 5.33.

Primary Metals

The primary metals sector includes iron and steel mills; steel pipe and tube mills; iron foundries; smelters; and aluminum, copper and other metal rolling, casting and extruding. In British Columbia this sector is dominated by two large companies, Alcan (aluminum) and Cominco (lead, zinc, and fertilizer). Together these companies consume over 80 percent of the energy requirements of the sector, primarily in the form of self-generated electricity.

Table 5.34 shows historical purchased energy, by fuel type, and self-generated electricity consumed by this sector over the period 1969 to 1975. Over this time period

TABLE 5.33

FORECAST ENERGY REQUIREMENTS
TOTAL NON-METALLIC MINERALS INDUSTRIES

(Quadrillion Joules)

	Natural Gas	R.P.P.	Electricity	L.P.G.	Total
1977	8.001	4.594	1.073	.078	13.746
1978	9.520	2.969	1.188	.081	13.758
1979	9.575	1.557	1.228	.083	12.443
1980	9.671	1.585	1.295	.086	12.637
1981	9.844	1.620	1.376	.089	12.929
1982	9.942	1.647	1.450	.092	13.131
1987	9.941	1.746	1.780	.110	13.577
1992	11.309	1.843	2.347	.128	15.626

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TABLE 5.34

HISTORICAL ENERGY CONSUMPTION IN THE PRIMARY METALS SECTOR

(Quadrillion Joules)

	Coal & Coke	R.P.P.	L.P.G.	Natural Gas	Purchased Electricity	Hydro Self. Gen. Electricity	Total
1969	8.549	.594	.071	1.679	6.816	30.910	48.619
1970	7.566	.560	.035	1.946	6.645	23.039	39.791
1971	6.949	.621	.032	2.205	5.790	28.486	44.083
1972	6.764	.557	.009	2.314	6.239	28.047	43.930
1973	6.712	.396	.006	2.304	5.306	27.308	42.032
1974	5.304	.325	.006	3.675	4.313	25.220	38.843
1975	5.559	.404	.008	4.997	5.228	22.600	38.796

SOURCE: Statistics Canada, Energy Services Bulletin, *Fuel and Electricity Purchased and Consumed By Manufacturing Industries* , Catalogue 57-002; and Industry Sources.

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energy consumption has been relatively stable, although labour-management problems in the industry have resulted in plant shut-downs for extended periods, for example, at Cominco in 1974.

Although total energy consumption has been relatively stable, the market shares of the various fuels have been changing. Of the total purchased energy, natural gas has increased its share at the expense of all other fuels, from around 13 percent in 1969 to over 45 percent by 1975. Self-generated electricity has maintained a relatively constant market share over this period at about 60-65 percent of total energy consumed in the sector.

Future Energy Requirements

(i) Requirements of Existing Facilities

The projection of future energy requirements in the primary metals sector was prepared using information received from Alcan and Cominco and from the Teck Corporation with regards to its new copper smelter. On the basis of this information it was possible to generate an energy requirements forecast by fuel type for these three companies.

In 1975 the energy consumed by Cominco and Alcan accounted for 82 percent of the total energy consumed in the primary metals sector. For the purpose of projecting energy requirements of the residual part of the sector, it was assumed that Cominco's and Alcan's share of the energy consumption would remain at 82 percent over the forecast period. Fuel shares in this sector were also assumed to stay constant at 1975 levels over the forecast period.

This forecast does not allow for any major conversion from one fuel type to another. It does, however, implicitly allow for some degree of conservation as the industry attempts to reduce its energy costs by improving the efficiency of energy use in the industrial process.

(ii) Requirements for New Facilities

The reliability of any forecast of future energy requirements for this sector depends critically on the occurence and timing of a number of large projects. For this reason the forecast is laid out in such a way that projects may be rescheduled to obtain alternate forecasts.

Over the period 1982 to 1992 it is assumed that three new developments in the primary metals sector will occur as the government adheres to a policy of maxmizing the value added to provincial resources. Explicit allowance is made for these projects based on the following assumptions:

(a) A second copper smelter will commence operation between 1982 and 1987. This smelter is assumed to have a capacity of 110,000 tonnes per year and will have an annual energy requirement of approximately 30 million m^3 of natural gas. The electricity component of energy required for a copper smelter is mostly used for mining and milling operations, and is thus included in the forecast of mining energy requirements.

(b) A third copper smelter will start operation sometime between 1987 and 1992. This smelter is assumed to have the same capacity and energy requirements as the smelter mentioned in (a).

(c) A direct reduction steel mill will be in operation, with a capacity of 1,000,000 tpy, by 1992. According to a feasibility study done by the International Steel Corporation,[29] the unit energy requirement for a mill of this type would be approximately 18.8 GJ/t; 16 percent of which would be supplied by electricity.

(d) The heat requirement for the third copper smelter and the steel mill will be supplied by coal. This energy requirement is included in the 1992 total.

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[29] *International Steel Corporation, A Feasibility Study and Proposal for an Integrated Steel Complex in British Columbia, undated.*

In accordance with the discussion above, Table 5.35 contains the forecast of energy requirements for existing and new facilities in the primary metals sector.

IV. Other Industries

Chemical and Chemical Products Industries

The chemicals and chemical products group includes manufacturers of fertilizers,[30] resins and plastics, pharmaceuticals, paints and varnishes, soap and cleaning compounds, toilet preparations, industrials chemcials and miscellaneous chemical products. In British Columbia the most energy intensive of these industries is industrial chemicals, which in 1975 accounted for approximately 95 percent of all the fuel and electricity consumed in this sector.

The historical energy requirements of the industry are presented in Table 5.36. Over the period 1965 to 1975 total energy consumption has followed a cyclical pattern. From 1965 to 1968 energy consumption grew rapidly; from 1968 to 1971 it leveled off; and since 1971 it has fallen again to pre-1968 levels. The figure for 1975 is lower due to shutdowns in the pulp industry, which has a direct impact on the production

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[30] *The energy used by Cominco's fertilizer plant is included in the primary metals sector since each company is classified by Statistics Canada according to its primary activity.*

TABLE 5.35

PRIMARY METALS SECTOR

Energy Requirements Forecast

(Quadrillion Joules)

	Total Energy	Purchased Elec.	Natural Gas	L.P.G.	R.P.P.	Coal & Coke	Self-Gen. Elec.
1977	44.088	5.547	5.339	.009	.362	6.510	26.315
1978	44.372	5.583	5.666	.009	.368	6.648	26.185
1979	45.393	5.712	5.673	.009	.366	6.731	26.902
1980	46.372	5.835	5.726	.009	.366	6.814	27.622
1981	47.322	5.954	5.811	.010	.364	7.201	27.982
1982	48.870	6.149	5.790	.010	.364	7.035	29.422
1987	58.936	7.139	8.253	.011	.431	8.278	34.824
1992	84.793	10.638	8.328	.012	.459	27.522	37.834

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TABLE 5.36

HISTORICAL ENERGY CONSUMPTION OF BRITISH COLUMBIA CHEMICAL AND CHEMICAL PRODUCTS INDUSTRY

(Quadrillion Joules)

Year	Natural Gas	R.P.P.	Electricity	Total
1965	1.75	.49	5.76	8.00
1966	1.89	.51	6.87	9.27
1967	2.08	.47	6.91	9.46
1968	2.55	.51	7.55	10.61
1969	2.17	.50	7.49	10.16
1970	2.19	.59	7.25	10.03
1971	2.44	.76	7.77	10.97
1972	2.56	.80	4.27	7.63
1973	3.11	.46	4.95	8.52
1974	2.62	.58	4.91	8.11
1975*	2.88	.60	3.19	6.67

Source: Statistics Canada, Purchased Fuel and Electricity in the Manufacturing Industries, Catalogue 57-002

* Catalogue 57-208

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of industrial chemicals and thus on energy consumed by this sector. Natural gas has increased its market share from 22 percent in 1965 to over 40 percent in 1975. Over the same period, electricity's market share has decreased from 72 percent to approximately 50 percent.

Industrial Chemicals

Chemical industries in British Columbia, with the exception of fertilizer manufacture are not, and do not appear likely to become,export-based. Rather, they produce primarily to meet final demand in British Columbia or, in the case of industrial chemicals, the input requirements of other export industries such as mining, forestry, pulp and paper and wood products. Industrial chemical plants tend to locate near the industries that they supply. Consequently, the development of major production of new classes of industrial chemicals is not foreseen.

Approximately 85 percent of the industrial chemicals output in British Columbia is purchased by the pulp and paper industry. The most important chemicals supplied are caustic soda and chlorine used for reducing chips and bleaching pulp. The production of these chemicals is extremely energy intensive, and their manufacture accounts for the bulk of industrial chemicals energy requirements. For this reasons, the forecast of energy requirements for the manufacture of industrial chemicals has been related to the forecast of market pulp.

Energy consumption by the industrial chemicals producers and the explanatory variable, pulp production, is shown below for 1975:

Market pulp production	2,362,000 ADT
Electricity	3.111 quadrillion joules
Natural gas	2.711 quadrillion joules
RPP	.498 quadrillion joules

The technical coefficient of joules per tonne for 1975 was 2.676 billion joules per ADT. It is assumed that this coefficient will prevail for the duration of the forecast period. The market pulp forecast is used to produce the energy requirements forecast shown in Table 5.37. It is also assumed that the fuel shares for 1975 are maintained over the forecast period.

Other Chemical Products

Paints produced in British Columbia are not generally exported, and output is closely related to the level of activity in the Province's construction industry. Output of plastics is largely confined to final processing and fabricating. The production of the basic plastics and resins in British Columbia would be prohibitively expensive and is

TABLE 5.37

FORECAST ENERGY REQUIREMENTS OF INDUSTRIAL, CHEMICALS PLANTS

(Quadrillion Joules)

Year	Market Pulp[1] Production (000 ADT)	Total Energy	Natural Gas	Electricity	R.P.P.
1976	3447	9.224	3.957	4.538	.729
1977	3020	8.081	3.467	3.967	.638
1978	3674	9.832	4.218	4.837	.777
1979	3794	10.153	4.356	4.995	.802
1980	3917	10.482	4.497	5.157	.828
1981	4044	10.822	4.643	5.324	.855
1982	4176	11.175	4.794	5.498	.883
1987	4443	11.889	5.100	5.849	.940
1992	4976	13.315	5.712	6.551	1.052

1. See Table 5.6

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not considered likely within the forecast period. Some explosives are manufactured in British Columbia at plants near mine sites. In addition, there is some packaging and fabrication of explosives products. Pharmaceuticals, soaps and toilet preparations are largely imported into the Province.

It is expected that over the forecast period there will be a reduction in the penetration of the domestic market by imports of some paints, pharmaceuticals and other consumer goods. Thus, growth in production of these goods should exceed the growth in overall provincial output. In order to allow for expansion in the production of these other chemicals and chemical products, it was assumed that energy requirements of these industries would grow at an annual rate of 5 percent. Table 5.38 includes the requirements of this sector.

Food and Beverage Industries

The food and beverage classification includes a wide variety of products, including meat, poultry and fish products, processed fruit and vegetable products, and dairy, cereal and bakery products. Table 5.39 shows the historical consumption of energy by these industries according to fuel type over the period 1965 to 1975. Energy requirements over this period have been growing at an average annual rate of less than 2 percent.

TABLE 5.38

FORECAST TOTAL ENERGY REQUIREMENTS IN CHEMICAL AND CHEMICAL PRODUCTS INDUSTRY

(Quadrillion Joules)

Year	Natural Gas	Electricity	R.P.P.	Total
1976	4.14	4.62	.83	9.59
1977	3.66	4.06	.75	8.47
1978	4.42	4.93	.89	10.24
1979	4.57	5.10	.91	10.58
1980	4.72	5.26	.95	10.93
1981	4.87	5.43	.99	11.29
1982	5.03	5.60	1.04	11.67
1987	5.40	5.98	1.14	12.52
1992	6.10	6.72	1.31	14.12

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TABLE 5.39

HISTORICAL ENERGY REQUIREMENTS IN THE FOOD AND BEVERAGES INDUSTRY

(Quadrillion Joules)

Year	R.P.P.	Natural Gas	L.P.G.	Electricity	Total
1965	2.242	2.734	.021	.482	5.479
1966	2.333	2.871	.020	.557	5.781
1967	1.962	3.002	.029	.618	5.611
1968	1.962	3.260	.027	.646	5.895
1969	1.841	3.159	.022	.672	5.694
1970	1.650	3.199	.023	.686	5.558
1971	1.646	3.115	.038	.737	5.536
1972	2.086	3.611	.035	.571	6.303
1973	1.873	3.641	.043	.950	6.507
1974	1.722	4.325	.053	.965	7.065
1975*	1.760	3.338	.061	1.075	6.234

Source: Statistics Canada Energy Services Bulletin (57-002)

* 57-208

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Because of the heterogeneity of the product mix in this industrial classification, a forecast of energy requirements by a method other than one which employs very simplifying assumptions is almost impossible. It does not appear worthwhile to attempt to increase the sophistication of the forecast of energy requirements for this sub-sector, in view of its low energy requirements relative to total industrial requirements.

Energy requirements of the food and beverage industries were projected on the assumption that growth in output, and hence energy usage, will parallel population growth. The use of this method may overstate requirements as historical energy use grew at an annual rate of approximately 1.3 percent between 1965 and 1975, while population growth over the same period was about 3.2 percent per annum.

Table 5.40 shows the forecast energy requirements by fuel type, for the food and beverage industries. The 1975 fuel shares have been assumed to remain constant over the forecast period.

Petroleum and Coal Products

The major industry within this group is petroleum refining, although manufacturers of petroleum and coal products such as charcoal briquettes, road emulsions, and roofing compounds also fall into this classification.

TABLE 5.40

FORECAST ENERGY REQUIREMENTS IN THE FOOD AND BEVERAGE INDUSTRY

(Quadrillion Joules)

Year	R.P.P.	Natural Gas	L.P.G.	Electricity	Total
1976	1.752	3.378	.063	1.064	6.257
1977	1.770	3.414	.063	1.075	6.322
1978	1.790	3.452	.064	1.086	6.392
1979	1.812	3.494	.065	1.100	6.471
1980	1.835	3.541	.065	1.114	6.555
1981	1.861	3.589	.066	1.130	6.646
1982	1.889	3.643	.067	1.147	6.746
1987	2.028	3.911	.072	1.231	7.242
1992	2.167	4.179	.077	1.315	7.738

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Table 5.41 shows historical energy consumption by this industrial group. It also contains estimates of the fuel requirement for petroleum refining per cubic metre of crude oil refined. The stability of this coefficient is indicative of the fact that petroleum refining accounts for the bulk of the fuel consumed by this group. It should be noted that electricity consumption is not taken into consideration in calculating the coefficient, since such consumption is not part of refinery fuel. Rather, electricity is required primarily for refinery instrumentation, pump drives, etc. Historically electricity consumption has grown at roughly the same rate as crude run to stills.

Table 5.41 illustrates the effect of the widening gap between natural gas and petroleum product prices, especially liquified petroleum gases (L.P.G.). As the price of LPG's has increased, it has become economic to substitute natural gas for fuel produced in the refinery. Refinery "own use" will continue, however, since some petroleum products continue to be produced which have little or no market value.

In order to forecast energy consumption by this group, it was assumed that the fuel coefficient would remain constant at the 1975 level (2.195 GJ/m^3 of crude run to stills).

TABLE 5.41

HISTORICAL ENERGY USAGE BY THE PETROLEUM AND COAL PRODUCTS INDUSTRY

Year	Refinery[1] Own Use	Natural[2] Gas	Total[3] Fuel	Electricity[2]	Run to[1] Stills	Fuel[4] Coefficient
	(Quadrillion Joules)				Thousand m^3	10^9 J/m^3
1965	8.75	.39	9.14	.586	4.72	1.936
1966	9.72	.43	10.15	.638	5.58	1.819
1967	10.89	.62	11.51	.710	6.01	1.915
1968	11.73	1.58	13.31	.851	6.55	2.032
1969	11.19	1.40	12.59	.888	6.23	2.021
1970	12.71	1.62	14.33	.972	6.98	2.053
1971	12.95	1.86	14.81	1.008	7.38	2.007
1972	13.20	2.69	15.89	.898	7.58	2.096
1973	13.27	3.44	16.71	.921	8.19	2.040
1974	13.68	5.29	18.97	.946	8.32	2.280
1975	13.69	4.21	17.90	1.018	8.16	2.194

1. Source: Statistics Canada Catalogue 45-204, Volume I (Refined Petroleum Products) to 1971 Catalogue 45-004 (Refined Petroleum Products) for 1972-1975. Assumes 30.53 Gj/m^3 (still gas).

2. Source: Statistics Canada Catalogue 57-002 (Energy Statistics Service Bulletin) to 1974 Catalogue 57-208 for 1975.

3. Sum of natural gas consumption and "own use".

4. Total fuel divided by crude run to stills.

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The forecast of refinery throughput was based on the forecast of refined petroleum products requirements as developed in this volume, including an allowance for liquified petroleum gases derived from refinery streams. Net petroleum products imports were assumed to stay constant at approximately 1.1 million m^3 per year or 19,000 barrels per day under the best estimate forecast. The resulting net RPP requirement to be supplied by domestic refineries was adjusted to account for fuel and losses; resulting refinery throughput is shown in Table 5.42. Based upon refinery capacities given in Table 5.43, it is anticipated that no additional capacity will be required until after 1987.[31]

The forecast energy requirements of the petroleum and coal products industry are shown in Table 5.42, along with the forecast of refinery throughput which underlies the forecast. The refinery fuel requirements are disaggregated into "own use" and natural gas requirements on the assumption that the share of "own use" requirements will decline from the current level of 4.8 percent of refinery throughput to 4.2 percent by 1992. Natural gas requirements are forecast as a residual. It is expected that natural gas will increase its share of fuel requirements slightly, from 31 percent in 1977 to 39 percent

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[31] *No change in throughput levels was assumed for either the high growth or coal conversion forecasts; increases or decreases in RPP requirements were assumed to be reflected entirely in changes in import levels.*

TABLE 5.42

FORECAST OF ENERGY CONSUMPTION BY THE PETROLEUM AND COAL PRODUCTS INDUSTRIES

	Refinery Throughput[1] (million/m^3/yr)	Refinery Fuel Requirements[2]	"Own Use"[3]	Natural Gas	Electricity	Total
			(Quadrillion Joules)			
1977	8.444	18.535	12.862	5.673	1.205	19.740
1978	8.809	19.336	13.418	5.918	1.257	20.593
1979	8.991	19.735	13.695	6.040	1.283	21.018
1980	9.195	20.183	14.006	6.177	1.312	21.495
1981	9.303	20.420	14.171	6.249	1.327	21.747
1982	9.442	20.725	14.382	6.343	1.347	22.072
1987	10.096	22,161	14.417	7.744	1.441	23.602
1992	11.087	24.336	14.777	9.559	1.582	25.918

1. Refinery throughput forecast was estimated on the basis of RPP requirements as developed in this volume, including an allowance for liquid petroleum gas production. Conversion factors used are 37.07 GJ/m^3.
2. Assumes a fuel coefficient held constant at the 1975 level of 2.195 GJ/m^3.
3. Assumed to be 4.8 percent of refinery throughput requirements until 1982. This share is assumed to decline to 4.5 percent by 1987 and 4.2 percent by 1992. Own use requirements are based on a conversion factor of 31.734 GJ/m^3 which represents a weighted average of energy content for still gas and crude oil.

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TABLE 5.43

CURRENT AND PROJECTED REFINERY CAPACITY IN BRITISH COLUMBIA

Company	Location	Gross Capacity (m^3/d)	Gross Capacity (million m^3/yr)
1977 Existing			
Gulf Oil	Port Moody	5915	2.158
Imperial Oil	Ioco	6360	2.321
Shell Oil	Burnaby	3546	1.294
Chevron Canada	Burnaby	5565	2.031
Gulf Oil	Kamloops	1367	0.499
Pacific Petroleums	Taylor	2210	0.807
Husky Oil	Prince George	1192	0.436
Total 1977		26155	9.546
1979 Approved Expansion			
Husky Oil	Prince George	397	0.145
Total 1979		26662	9.691
1980+ Approved Expansion			
Chevron Canada	Burnaby	1588	0.580
Total 1980+		28140	10.271
1985 Projected			
Capacity bottlenecks		635	0.232
Total 1985+		28775	10.503

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by the end of the forecast period. Electricity consumption is assumed to increase at the same rate as refinery throughput, in line with recent historical experience.

Other Manufacturing Activities

This category is comprised of a variety of manufacturing industries that, though they consume negligible amounts of energy in British Columbia, may be large energy users in other provinces. Industries in this group include rubber and plastics products, textiles, clothing, furniture and fixtures, printing and publishing, metal fabricating, machinery, transportation equipment, electrical products and miscellaneous manufacturing. Forecasting the energy consumption of this sector is difficult because of the diversity of its output, but important because it is in this sector that the likelihood of unforeseen change is the highest.

Historical Energy Use

Table 5.44 shows the record of energy consumption by fuel type by Other Manufacturing Activities over the period 1965 to 1975. Over this period, total energy consumption grew at an average annual rate of 6.6 percent, from 1.940 quadrillion joules to 3.670 quadrillion joules. In 1975, this group of industries accounted for only 2.8 percent of total purchased fuel and electricity consumed by manufacturing industries. Of these industries, the largest energy users are metal fabricating, accounting for 41 percent of the total fuel and electricity used; transportation equipment, 17 percent;

TABLE 5.44

HISTORICAL ENERGY CONSUMPTION IN OTHER MANUFACTURING ACTIVITIES

(Quadrillion Joules)

Year	R.P.P.	Natural Gas	L.P.G.	Electricity	Total
1965	.68	.73	.02	.51	1.94
1966	.65	.91	.02	.64	2.22
1967	.60	.99	.01	.71	2.31
1968	.55	1.06	.02	.81	2.44
1969	.64	1.11	.03	.90	2.68
1970	.62	1.38	.02	.92	2.94
1971	.62	1.52	.03	.99	3.16
1972	.63	1.77	.03	1.02	3.45
1973	.65	1.86	.05	1.08	3.64
1974	.70	1.93	.04	1.10	3.77
1975*	.58	1.96	.06	1.07	3.67

Source: Statistics Canada Energy Service Bulletin (57-002)
* Catalogue 57-208

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machinery manufacturing, 14 percent; printing and publishing, 8 percent; and electrical products, 6 percent.

Over the historical period, the fuel share of natural gas has been steadily increasing, while that of refined petroleum products has been steadily declining. Natural gas has increased its market share from 37.6 percent in 1965 to 53.4 percent in 1975. Refined petroleum products market share decreased from 35.8 percent to 15.8 percent over this same period. The fuel shares of electricity and L.P.G.'s stayed relatively constant over this ten year period.

Projected Energy Use

As was mentioned earlier, it is extremely difficult to trace the factors that govern growth in this sector which comprises many small industrial concerns. It is believed, however, that growth will continue with energy demand over the forecast period increasing at the same average rate of 6.6 percent per annum.

Growth in energy demand of this magnitude may actually imply a higher rate of growth in real output and employment by this sector of industries. With rising energy prices, there will be a continued push for more efficient use of energy in these industries.

The industries in which this expansion is to take place are uncertain, thus making it impossible to be precise about the future fuel split. Therefore, the 1975 fuel split has been assumed to prevail over the forecast period.

Table 5.45 contains the forecast by fuel type for Other Manufacturing Activities.

TABLE 5.45

FORECAST ENERGY REQUIREMENTS
OTHER MANUFACTURING ACTIVITIES

(Quadrillion Joules)

Year	R.P.P.	Natural Gas	L.P.G.	Electricity	Total
1976	.59	2.11	.06	1.15	3.91
1977	.63	2.25	.06	1.23	4.17
1978	.67	2.40	.07	1.31	4.45
1979	.71	2.56	.07	1.40	4.74
1980	.76	2.72	.08	1.49	5.05
1981	.81	2.91	.08	1.59	5.39
1982	.86	3.10	.09	1.69	5.74
1987	1.18	4.27	.12	2.33	7.90
1992	1.62	5.87	.17	3.21	10.87

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CHAPTER 6

TRANSPORTATION SECTOR

The transportation sector includes both private and commercial motor vehicles, air transport, marine transport and rail transport. This chapter contains four sub-sections in which the energy requirements of each of the above mentioned transportation modes are forecast.

Almost all energy requirements in the transportation sector are supplied by petroleum products, and this characteristic is expected to prevail over the forecast period. The possibility of electricity capturing part of this sector's energy requirement (in motor vehicles, rapid transit and railways) has been considered but no allowance is made in this forecast for the event.

With the exception of motor vehicles, only one forecast of energy requirements was made for each transportation mode. In the case of motor vehicles, two forecasts were made: a baseline estimate which assumes for comparison purposes, no increase in average fuel economy after 1979 and one based on assumed target improvements in fuel economy. Table 6.1 contains the forecast of energy requirements in the transportation sector.

The most striking feature of the forecast requirements for this sector is the fact that, by 1992, total fuel consumption by private passenger automobiles is forecast to be less than the 1977 level. This is a result of the assumption that measures recently introduced in the United States to induce automobile manufacturers to increase the fuel economy of new automobiles will also be adopted voluntarily in Canada over the next decade. These measures are discussed in more detail in the section on motor vehicles.

As implied by the figures contained in Table 6.1, the expected average growth rate of energy requirements under the baseline estimate is 2.7 percent per annum over the forecast period. This compares with a 1.8 percent per annum rate implied by the forecast, which includes greatly improved fuel economy in motor vehicles. The impact of conservation in this sector is therefore extremely significant.

I. Motor Vehicles

To estimate future energy requirements, motor vehicles have been classified into two categories; passenger vehicles and general commercial vehicles. Passenger vehicles include both private and commercial passenger cars, whereas general

TABLE 6.1

FORECAST ENERGY REQUIREMENTS IN THE TRANSPORTATION SECTOR

(Quadrillion Joules)

	Motor Vehicles		Air Transport	Marine Transport	Rail Transport	Total	
	I	II				I	II
1977	137.16	137.16	17.95	18.75	15.16	189.02	189.02
1978	142.69	142.69	18.60	19.12	16.01	196.42	196.42
1979	146.51	146.51	19.28	19.41	16.48	201.68	201.68
1980	150.10	150.41	19.99	19.71	16.97	206.77	207.08
1981	153.00	154.33	20.72	20.00	17.52	211.24	212.57
1982	154.45	157.54	21.49	20.29	18.10	214.33	217.42
1987	155.72	176.08	25.35	22.23	23.25	226.55	246.91
1992	167.21	200.12	29.29	24.55	26.06	247.11	280.02

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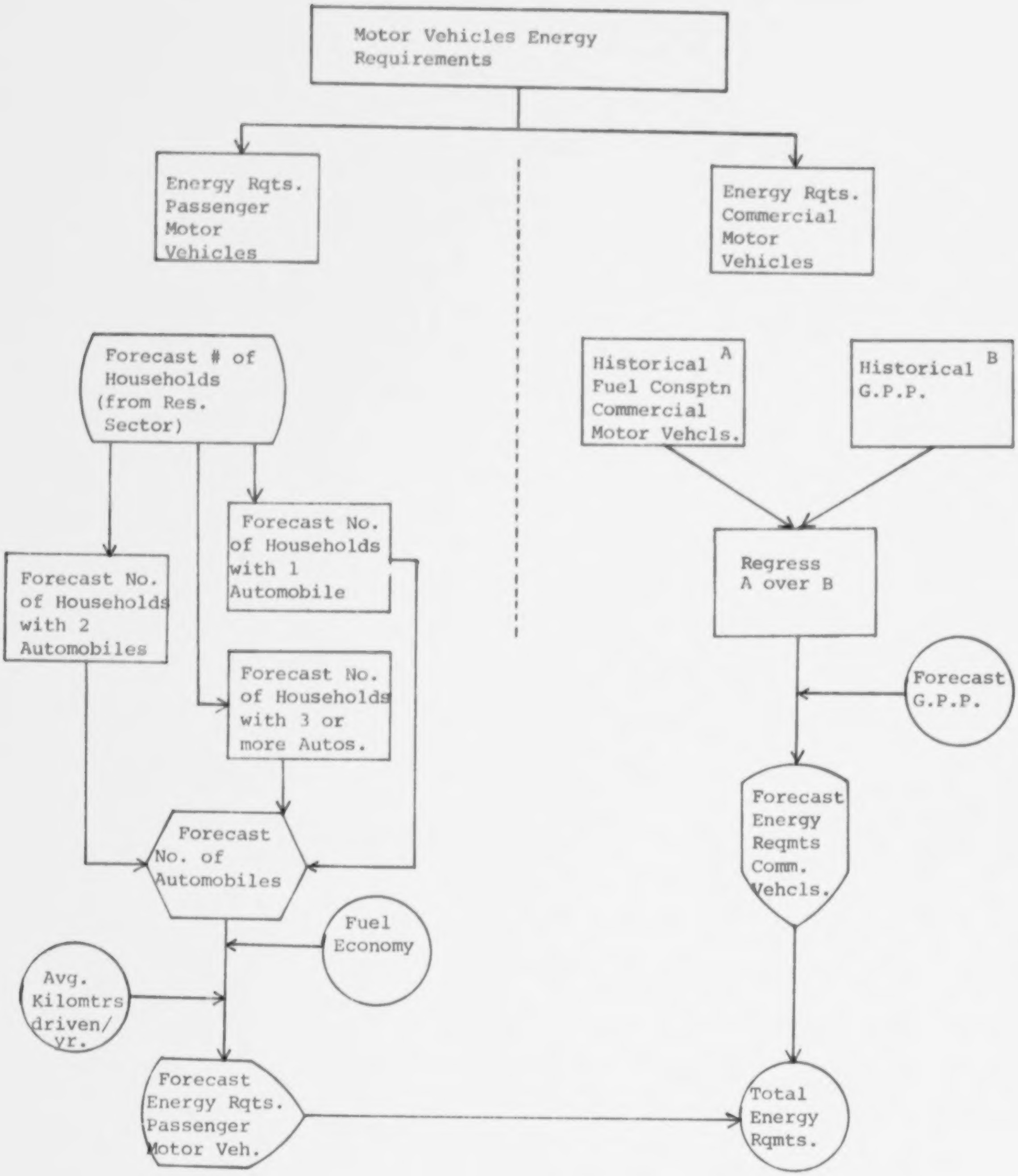
commercial vehicles include motor trucks, truck tractors, buses and ambulances, etc. Fuel consumed by each vehicle category was forecast separately. Fuel used by taxis, rental vehicles, motor cycles and military vehicles is accounted for together within energy used by passenger motor vehicles.

The energy requirements forecast for passenger vehicles is based on a forecast of the number of passenger vehicles in operation, the average number of kilometres driven per year, and the fuel economy of new passenger cars. For general commercial vehicles, energy requirements are forecast on the basis of future economic activity measured in terms of Gross Provincial Product. Figure 6.1 summarizes the methodology employed.

It is possible that electric cars and expanded rapid transit systems in the GVRD will be introduced during the forecast period. However, no attempt is made in this forecast to quantify the impact of either of these developments on petroleum product consumption by motor vehicles. It is believed that even if such changes were to occur, they would not lead to significant increases in the demand for electricity before 1992. However, longer term forecasts should carefully examine this issue, particularly in the context of the demand for electricity. Similar comments apply with respect to automobiles operating on such fuel sources as methanol, LPG, and Liquefied Natural Gas.

FIGURE 6.1

FLOW CHART
ROAD TRANSPORT ENERGY FORECAST


Motor Vehicles Energy Requirements
Energy Rqts. Passenger Motor Vehicles
Energy Rqts. Commercial Motor Vehicles
Forecast # of Households (from Res. Sector)
Forecast No. of Households with 1 Automobile
Forecast No. of Households with 2 Automobiles
Forecast No. of Households with 3 or more Autos.
Forecast No. of Automobiles
Fuel Economy
Avg. Kilomtrs driven/ yr.
Forecast Energy Rqts. Passenger Motor Veh.
Historical Fuel Consptn Commercial Motor Vehcls. A
Historical G.P.P. B
Regress A over B
Forecast G.P.P.
Forecast Energy Reqmts Comm. Vehcls.
Total Energy Rqmts.

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Fuel Economy in Passenger Motor Vehicles

The fuel economy of passenger cars depends upon many factors, including the manner in which the vehicle is driven, the frequency of cold starts, the use of power absorbing accessories, axle ratio, and vehicle weight.

In 1975, a new Energy Conservation Act was introduced in the United States, requiring that all automobiles manufactured in the U.S. achieve specified sales-weighted consumption levels. Subsequent to this, the federal government in Ottawa announced similar fuel economy targets for automobiles manufactured in Canada. However, Canada has no legislation which makes it mandatory for automobile manufacturers to ensure that cars manufactured in Canada meet the target fuel economy standards. Rather, these target fuel economy levels are to be obtained on a voluntary basis.

In spite of the voluntary nature of the program to improve fuel economy of passenger vehicles, it can be expected that similar fuel savings will occur in Canada as those mandated in the U.S. This is because all Canadian subsidiaries to U.S. parent companies manufacture vehicles to meet the United States E.P.A. (Environment Protection Agency) standards. Also, the mix of Canadian vehicle purchases, from full size to sub-compact, is similar to that in the U.S. It is therefore anticipated that the following average fuel economies will be achieved by the cars operating on British Columbia highways:

Model Year	Fuel Economy Standards (litres/100 km)
1979	12.4
1980	11.8
1981	10.7
1982	9.8
1983	9.0
1984	8.7
1985	8.6

Source: Ministry of Transport, Ottawa

The fuel economy standards described in the above table are based on the United States E.P.A. ratings and represent the sales-weighted average taken over all passenger automobiles sold by any single manufacturer. The E.P.A. rating procedure simulates both highway and city driving conditions to evaluate fuel economy. For large vehicles, it is generally observed that the E.P.A. rating over-estimates the fuel economy that can be achieved under real driving conditions. When considering an average overall type of vehicle (large and small), however, the discrepancy appears to balance out.

Energy Requirements Forecast

A. Energy Requirements for Passenger Motor Vehicles

The forecast of energy requirements for passenger automobiles is based on projections of the number of automobiles in service, the average number of kilometres driven per automobile per year, and the fuel economy of automobiles in service.

The number of automobiles is projected using the household forecast, and forecasts of number of households owning one automobile, two automobiles, and three or more automobiles. Historically, there has been a gradual shift in the proportion of households owning two or more automobiles. For example, the proportion of households with one automobile declined from 56 percent in 1967 to 48 percent in 1976; correspondingly, the proportion of households owning two or more automobiles increased from 25 percent in 1967 to 32 percent in 1976. About 17 percent of the households did not own any automobile in 1976, as compared to 19 percent in 1967 (see Table 6.2). These shifts in car ownership patterns probably reflect the improved economic conditions of the average household in British Columbia. Also, in part, the increase in the number of households owning two or more automobiles is attributable to increased participation of both spouses in the labour force.

TABLE 6.2

HISTORICAL SHARES OF HOUSEHOLDS OWNING ONE AUTOMOBILE, TWO AUTOMOBILES, AND THREE OR MORE AUTOMOBILES

	Shares of Household Owning				Estimated Automobiles per Household
	One Auto	Two Autos	Three or More Autos	No Auto	
1967	0.56	0.21	0.04	0.19	1.12
1968	0.56	0.21	0.04	0.19	1.12
1969	0.55	0.22	0.04	0.19	1.13
1970	0.55	0.23	0.05	0.17	1.18
1971	0.53	0.24	0.05	0.18	1.19
1972	0.52	0.25	0.05	0.18	1.20
1973	0.49	0.26	0.06	0.19	1.22
1974	0.48	0.28	0.06	0.18	1.25
1975	0.48	0.28	0.06	0.17	1.28
1976	0.48	0.28	0.06	0.17	1.29

Source: Statistics Canada Household Facilities and Equipment, 64-202.

The number of passenger automobiles has been forecast to 1992 by projecting the number of households with one automobile, two automobiles, and three or more automobiles. These three forecasts have been derived on the basis of trends in their respective historical shares. Table 6.3 lists number of automobiles, number of households, and average number of automobiles per household over the forecast period to 1992.

To account for other commercial passenger automobiles, for example, taxicabs and rental vehicles, it is assumed that these automobiles will continue to comprise approximately 2 percent of passenger motor vehicles. Therefore, the forecast number of automobiles derived above, was adjusted upward by applying a factor of 1.02. These adjusted numbers are also contained in Table 6.3.

On the basis of the household forecast and the forecast of number of automobiles, the automobile per household ratio is projected to increase from 1.31 in 1978 to 1.51 by 1992.

The number of automobiles so obtained was further disaggregated according to model year. In making this disaggregation, it is assumed that at any time in the forecast period the stock of automobiles is a heterogeneous mixture of models up to fifteen years old. Figure 6.2 depicts the assumed car age distribution which was derived on the basis

TABLE 6.3

FORECAST NUMBER OF AUTOMOBILES AND AUTOMOBILES PER HOUSEHOLD RATIO

	Households	Automobiles	Adjusted Automobiles[1]	1978-1992 Automobiles per Household
1977	850,820	1,084,378	1,106,066	1.30
1978	874,004	1,123,095	1,145,557	1.31
1979	897,927	1,162,815	1,186,071	1.32
1980	922,599	1,203,992	1,228,072	1.33
1981	948,046	1,256,160	1,281,283	1.35
1982	966,021	1,289,638	1,315,431	1.36
1987	1,058,982	1,503,754	1,533,829	1.45
1992	1,149,699	1,707,304	1,741,450	1.51

1. These adjusted numbers include taxicabs and rental vehicles.

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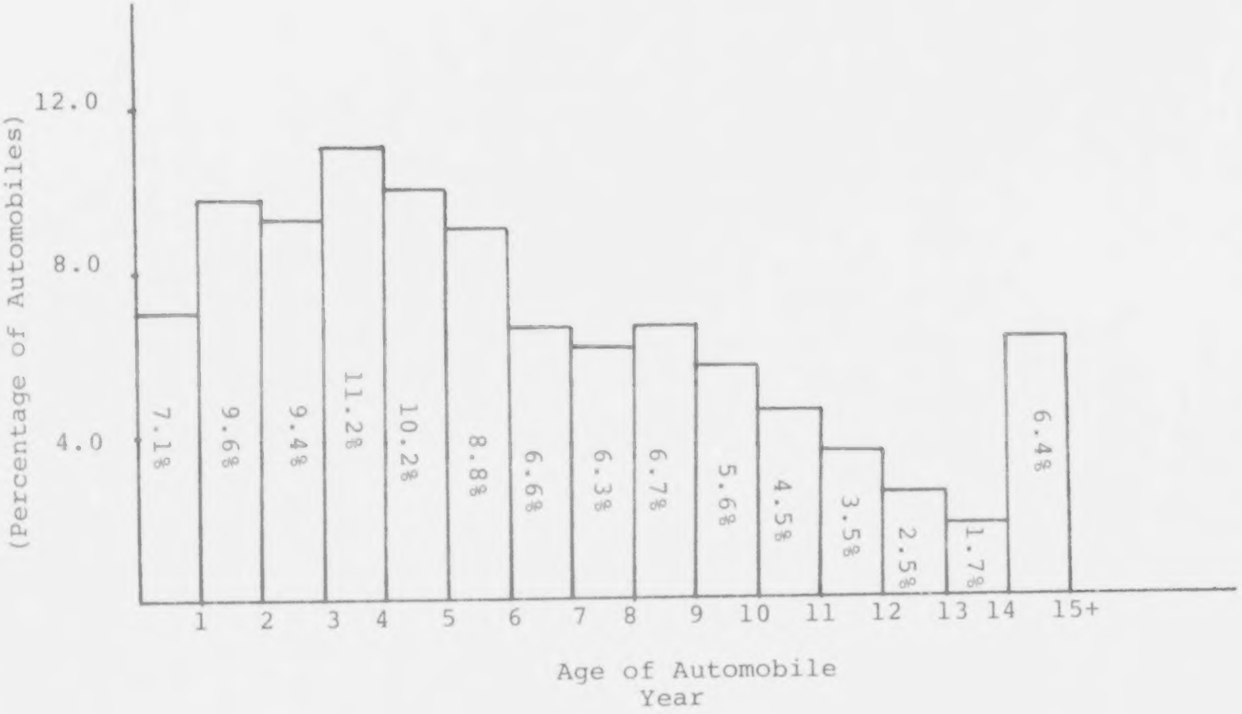
FIGURE 6.2

DISTRIBUTION OF AUTOMOBILES BY AGE GROUP IN A GIVEN YEAR



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of information obtained from the Insurance Corporation of British Columbia.

The energy consumption in a given year depends on the fuel economy of all new and used cars in operation during the year. While estimating future energy requirements, no distinction was made between first and second cars. It can be argued that second cars, since they are generally used for city driving, have lower fuel economy than first cars. Any such effect, however, would be largely offset by the fact that most second cars are more often of small size and therefore have higher E.P.A. estimated fuel economy.

The fuel economy for 1966-1977 model year passenger automobiles operating in British Columbia is summarized in the following table.

Model Year	Fuel Economy (litres/100 km)
1966	15.9
1967	15.0
1968	14.4
1969	13.6
1970	12.5
1971	13.6
1972	15.1
1973	15.4
1974	15.9
1975	15.4
1976	14.7
1977	12.7
1978	12.5

The primary objective of the energy efficient standards shown previously is to promote energy conservation in the transportation sector. To quantify the effect of these fuel economy levels, a baseline case was developed assuming that the fuel economy of all passenger vehicles operated in British Columbia would not improve after 1979. The conservation and baseline forecasts are termed Projection 1 and Projection 2 respectively.

A final assumption is that passenger vehicles are driven an average of 16,734 kilometres per year. On the basis of this assumption the total annual energy requirements for all passenger automobiles over the forecast period may now be readily computed.[1] Results are reported in Table 6.5.

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[1]

$$E = \sum_{t=1}^{15} (N(t).F(t))\ .\ 167.34$$

where: E = total energy requirements for passenger automobiles in any given year

$N(t)$ = number of passenger automobiles $t-1$ to t year old. (For example, $t=1$ implies total number of passenger vehicles that are almost one year old)

$F(t)$ = average fuel economy of automobiles $t-1$ to t year old (in litres/100 km).

B. Energy Requirements for General Commercial Vehicles

The category of general commercial vehicles includes motor trucks, truck tractors, buses, ambulances and similar vehicles. Off-highway road vehicles and trucks used in logging, mining and other industries are, however, excluded.

The level of commercial vehicle activity in the province appears to be quite closely related to the level of industrial and business activity, and hence to the Gross Provincial Product. Therefore, a simple regression of historical fuel consumption by commercial vehicles on Gross Provincial Product is employed for the forecasting equation.[2] The forecast of Gross Provincial Product used for this purpose is identical to that described in Chapter II.

Historical fuel consumption data employed for estimating the regression coefficients is contained in Table 6.4.

Because of the growing emphasis on energy conservation, some reduction in the average fuel consumption by commercial vehicles is anticipated as a result of improvements in engine

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[2] *The resulting regression equation is:*

Fuel consumption by commercial vehicles (in 10^{15} *joules)*
= $-14.71 + 2.66$ *GPP (in billions of dollars):* $R^2 = 0.99$.

TABLE 6.4

HISTORICAL CONSUMPTION OF MOTOR GASOLINE AND DIESEL OIL BY GENERAL COMMERCIAL MOTOR VEHICLES IN B.C.[1]

Year	Net Sale of Gasoline[2] litres	Net Sale of Gasoline[2] Quad. Joules	Net Sale of Diesel Oil litres	Net Sale of Diesel Oil Quad. Joules	Total joules
1966	419,547,918	14.54	124,114,634	4.80	19.34
1967	445,950,411	15.45	132,048,647	5.11	20.56
1968	477,540,499	16.55	141,034,968	5.45	22.00
1969	511,391,171	17.72	164,591,016	6.37	24.09
1970	542,068 095	18.78	178,857,896	6.92	25.70
1971	577,612,364	20.02	244,420,865	9.45	29.47
1972	611,592,598	21.19	291,828,356	11.29	32.48
1973	679,085,924	23.53	342,126,632	13.23	36.76
1974	727,297,479	25.20	380,760,864	14.72	39.92

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[1] Source: Statistics Canada Cat. The Motor Vehicle Part II (53-218)

[2] These figures are 22 percent of the net sale of gasoline in B.C. was reported in the catalogue. 22 percent is estimated from 1973 data.

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efficiency. To account for this reduction in fuel consumption, it is assumed that, up to 1982, fuel savings for commercial vehicles will be of the same order as in the case of passenger vehicles. For the remainder of the forecast period, a 10.0 percent reduction in fuel consumption is assumed to project energy requirements for non-passenger vehicles. This forecast is included in Table 6.5.

C. Total Energy Requirements for Motor Vehicles

Combining the results of sub-sections A and B above, the total energy requirements forecast for motor vehicles in the province is obtained. Table 6.5 contains this total energy requirements forecast, along with the projected energy requirements for passenger motor vehicles and commercial motor vehicles separately. The energy requirements for passenger vehicles are forecast to reach a peak of 100.58 quadrillion joules in 1981 and then to decrease gradually thereafter to a low of 92.50 quadrillion joules under Projection 1. This decrease in fuel requirements is a result of newer cars with better fuel economy replacing older, less efficient cars.

TABLE 6.5

FORECAST ENERGY REQUIREMENTS FOR MOTOR VEHICLES IN BRITISH COLUMBIA

(Quadrillion Joules)

Year	Passenger Motor Vehicles Projection I	 Projection II	Non-Passenger Motor Vehicles	Total Projection I	 Projection II
1978	96.33	96.33	46.36	142.69	142.69
1979	98.00	98.00	48.51	146.51	146.51
1980	99.30	99.61	50.80	150.10	150.41
1981	100.58	101.91	52.42	153.00	154.33
1982	99.94	103.03	54.51	154.45	157.54
1987	93.83	114.19	61.89	155.72	176.08
1992	92.50	125.41	74.71	167.21	200.12

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Energy use by commercial vehicles is forecast to increase from 46.36 quadrillion joules in 1978 to 74.71 quadrillion joules in 1992. The total energy requirements for motor vehicles are projected to increase at a rate of 1.1 percent per annum from 142.69 quadrillion joules in 1978 to 167.21 quadrillion joules in 1992 under Projection 1. Under Projection 2, the baseline scenario, the growth rate in total energy requirements is expected to be 2.4 percent per annum.

II. Air Transport

Air mode consumption includes jet fuel and aviation gasoline for both freight and passenger transport, by commercial, government and private aircraft.

Commercial air traffic in British Columbia is serviced by both Canadian and foreign airlines. The Canadian Transport Commission has classified Canadian air carriers into five groups according to their size and annual revenues. Air Canada, C.P. Air, and Pacific Western are the three regional carriers in the first two groups, which, along with 78 other carriers from the remaining three groups, shared about 78 percent of the British Columbia aviation fuel market in 1976. Foreign commercial airlines accounted for about 12 percent and government and private aircraft accounted for the remainder of British Columbia's aviation fuel consumption.

Because of the international and interregional character of air transport,any analytical study of its fuel consumption in a provincial context is hampered by several data limitation problems. Foremost among these is the problem of measuring the output associated with British Columbia fuel consumption.

In this forecast of total fuel consumption by air transport in British Columbia, the requirements of the following three types of air carriers have been projected separately:

i) Canadian air carriers (including international schedules and chartered service);

ii) Foreign air carriers;

iii) Government and private air carriers.

Figure 6.3 depicts the methodology employed.

Table 6.6 gives the historical consumption of aviation fuel by these three groups of air carriers and their respective market shares for the years 1965 to 1976. Over this period, total fuel consumption by this sector has grown at an average annual rate of 9.1 percent.

Fuel Consumption by Canadian Air Carriers

As was noted above, Canadian air carriers account for over 78 percent of total aviation fuel consumed in British Columbia in 1976. Fuel consumption in British Columbia by this

FIGURE 6.3

FLOW CHART
AIR TRANSPORT ENERGY FORECAST

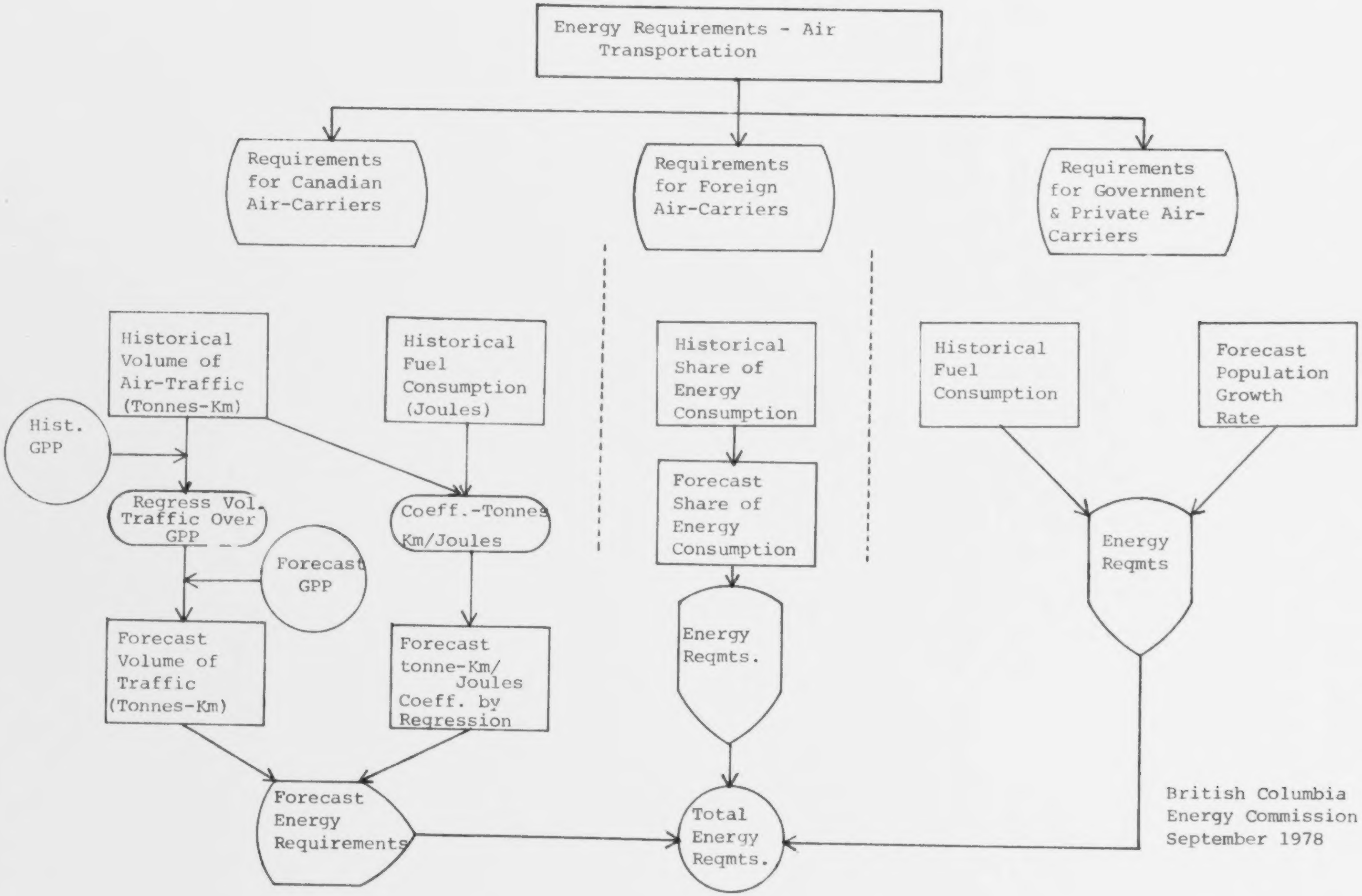
Energy Requirements - Air Transportation
Requirements for Canadian Air-Carriers
Requirements for Foreign Air-Carriers
Requirements for Government & Private Air-Carriers
Historical Volume of Air-Traffic (Tonnes-Km)
Hist. GPP
Regress Vol. Traffic Over GPP
Forecast GPP
Forecast Volume of Traffic (Tonnes-Km)
Historical Fuel Consumption (Joules)
Coeff.-Tonnes Km/Joules
Forecast tonne-Km/ Joules Coeff. by Regression
Forecast Energy Requirements
Historical Share of Energy Consumption
Forecast Share of Energy Consumption
Energy Reqmts.
Total Energy Reqmts.
Historical Fuel Consumption
Forecast Population Growth Rate
Energy Reqmts

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TABLE 6.6

HISTORICAL FUEL CONSUMPTION DATA FOR AIR TRANSPORT IN BRITISH COLUMBIA

(Quadrillion Joules)

	Commercial				
	Canadian Air Carrier*	Foreign Air Carrier	Sub Total	Others	Total
1965	4.06	.01	4.07	1.91	5.98
1966	5.23	.04	5.27	2.21	7.48
1967	5.89	.04	5.93	2.50	8.43
1968	6.52	.06	6.58	2.52	9.10
1969	7.59	.23	6.82	2.68	9.50
1970	9.66	.32	9.98	2.22	12.20
1971	8.89	.95	9.84	2.36	12.20
1972	9.39	.74	10.13	2.38	12.41
1973	11.36	1.10	12.46	2.67	15.13
1974	12.54	1.03	13.57	1.71	15.28
1975	13.41	2.31	15.72	2.33	18.05
1976	13.83	2.11	15.94	1.71	17.65

* Includes international traffic.

Source: Statistics Canada 45-208.

group of air carriers has grown at an average annual rate of 11.8 percent from 1965 to 1976.

Fuel consumption by an aircraft depends upon a large number of factors, some of which, such as meteorological conditions, can be assumed constant over the forecast period and will not significantly affect future fuel consumption.

To meet the volume of traffic over the forecast period these airlines will have to increase their productivity. It is therefore expected that the airlines will improve both the size and type of their fleets.

In order to make a forecast of future fuel consumption, coefficients of passenger and freight tonne-kilometres per quadrillion joules were first derived from national data. From the information on the volumes of fuel loaded on aircraft in British Columbia an estimate of the number of tonne-kilometres attributable to consumption of aviation fuel in British Columbia over the forecast period was made. Table 6.7 contains these historical estimates as well as historical Gross Provincial Product.

The two key variables--tonne-kilometres and tonne-kilometres per quadrillion joules--were estimated by simple regression analysis. First, the number of tonne-kilometres

TABLE 6.7

HISTORICAL G.P.P. & FUEL CONSUMTPION BY CANADIAN AIR CARRIERS IN BRITISH COLUMBIA

	Passenger and Freight Tonne-km/10^{15}J*	Fuel Consumed in B.C.	Tonne-km Credited to B.C. Fuel	G.P.P. (1976$)
	(10^6)	(Quadrillion Joules)	(10^6)	(10^6)
1965	23.149	4.062	94.031	11,569
1966	22.851	5.233	119.579	12,506
1967	23.240	5.887	136.814	13,062
1968	23.516	6.520	153.324	13,831
1969	25.522	7.586	193.610	14,989
1970	26.264	9.664	253.815	15,330
1971	26.400	8.897	234.881	16,658
1972	28.432	9.390	266.976	17,759
1973	29.115	11.363	330.834	19,441
1974	29.076	12.545	364.758	20,189
1975	29.519	13.410	395.850	20,193
1976	30.178	13.832	417.422	21,304

* Nationwide coefficient for Levels I to IV Canadian Air Carriers.

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attributable to British Columbia fuel consumption was regressed[3] on historical Gross Provincial Product, on the assumption that this variable and air transport activity are closely related. Application of this equation to the forecast of GPP[4] provides a forecast of air transport activity related to Canadian air carriers.

Secondly, historical values of the productivity coefficients (t-km/quadrillion joules) were regressed[5] on time to account for improvements in productivity due to technological changes and improved utilization of the aviation fuel. Examples of improved productivity include increased use of wide body aircraft, removal of first class seats on short haul services, and higher load factors through better scheduling of aircraft. Use of this equation provides the forecast of tonne-kilometres per thousand quadrillion joules.

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[3] *Tonne-km attributable to B.C. fuel = (.03217)(GPP)-282.0932;* $R^2=.96$.

[4] *The forecast of GPP used here is the same as that presented in Chapter 2.*

[5] *Productivity coefficient* $(t\text{-}km/10^{15}j) = (.7735)\ time + 21.4575$; $R^2=.95$.

Combination of these two forecasts produces the final forecast of energy requirements by Canadian air carriers. Table 6.8 contains these three forecasts.

Fuel Consumption by Foreign Air Carriers, Government and Private Aircraft

Fuel consumption by foreign air carriers increased from .01 quadrillion joules in 1965 to 2.11 quadrillion joules in 1976. Foreign air carriers have increased their market share of British Columbia aviation fuel consumption from less than 1 percent in 1965 to over 13 percent in 1976. As the personal income of Canadians increases, there will be more demand for international passenger service. Plus, as the Canadian tourist trade grows, there will be more demand for passenger service to Canada, for example, from Japan. This growth in international traffic implies that even with keen competition between foreign and Canadian airlines on these routes, foreign airlines will continue to increase their share of the total market in British Columbia. Hence, it was assumed that the foreign airlines' share of total aviation fuel consumption in British Columbia will increase over the forecast period.

Fuel consumption by government and private aircraft was less in 1976 (1.71 quadrillion joules) than in 1965 (1.91 quadrillion joules). During that period, however, fuel

TABLE 6.8

FORECAST ENERGY REQUIREMENTS BY CANADIAN AIR CARRIERS IN BRITISH COLUMBIA

	G.P.P. (1976$)	Tonne-Km	Tonne-Km per Quadrillion Joules	Fuel Requirements
	(10^6)	(10^6)	(10^6)	(Quadrillion Joules)
1977	22,163.9	430.918	31.513	13.674
1978	22,939.4	455.866	32.287	14.119
1979	23,752.7	482.030	33.060	14.580
1980	24,605.4	509.461	33.834	15.058
1981	25,498.8	538.202	34.607	15.552
1982	26,435.8	568.345	35.381	16.064
1987	31,364.8	726.911	39.248	18.521
1992	36,704.8	898.700	43.116	20.844

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consumption by this group of aircraft increased to a high of 2.68 quadrillion joules in 1969 and has fluctuated widely since then. For the purposes of this forecast,fuel consumption by government and private aircraft was assumed to increase at the same rate as population,on the basis that demand for private aircraft usage in particular is highly correlated with the level of population.

The projected values for aviation fuel consumption by all three air transport categories and total aviation fuel consumption by air transport in British Columbia are given in Table 6.9. The annaul average growth rate is 3.3 percent.

III. Marine Transport

Marine transport fuel consumption includes consumption of heavy fuel oil and diesel fuel oil by Canadian or foreign owned, for hire, shipping companies operating in water adjacent to the Pacific coast or in the interior of the Province. Consumption of energy by the fishing fleet based in British Columbia is included in the non-building component of the commercial sector.

Total energy requirements are forecast by making two separate forecasts--one for all those carriers primarily engaged in international and domestic trade and a second for ferries operated by the British Columbia Ferry Corporation and ferries

TABLE 6.9

FORECAST ENERGY REQUIREMENTS FOR TOTAL AIR TRANSPORT IN BRITISH COLUMBIA

(Quadrillion Joules)

	Canadian Air Carriers	Foreign Air Carriers	Other	Total
1977	13.674	2.513	1.760	17.947
1978	14.119	2.697	1.783	18.599
1979	14.580	2.892	1.806	19.281
1980	15.058	3.098	1.830	19.986
1981	15.552	3.315	1.853	20.720
1982	16.064	3.545	1.877	21.486
1987	18.521	4.817	2.015	25.353
1992	20.844	6.297	2.149	29.290

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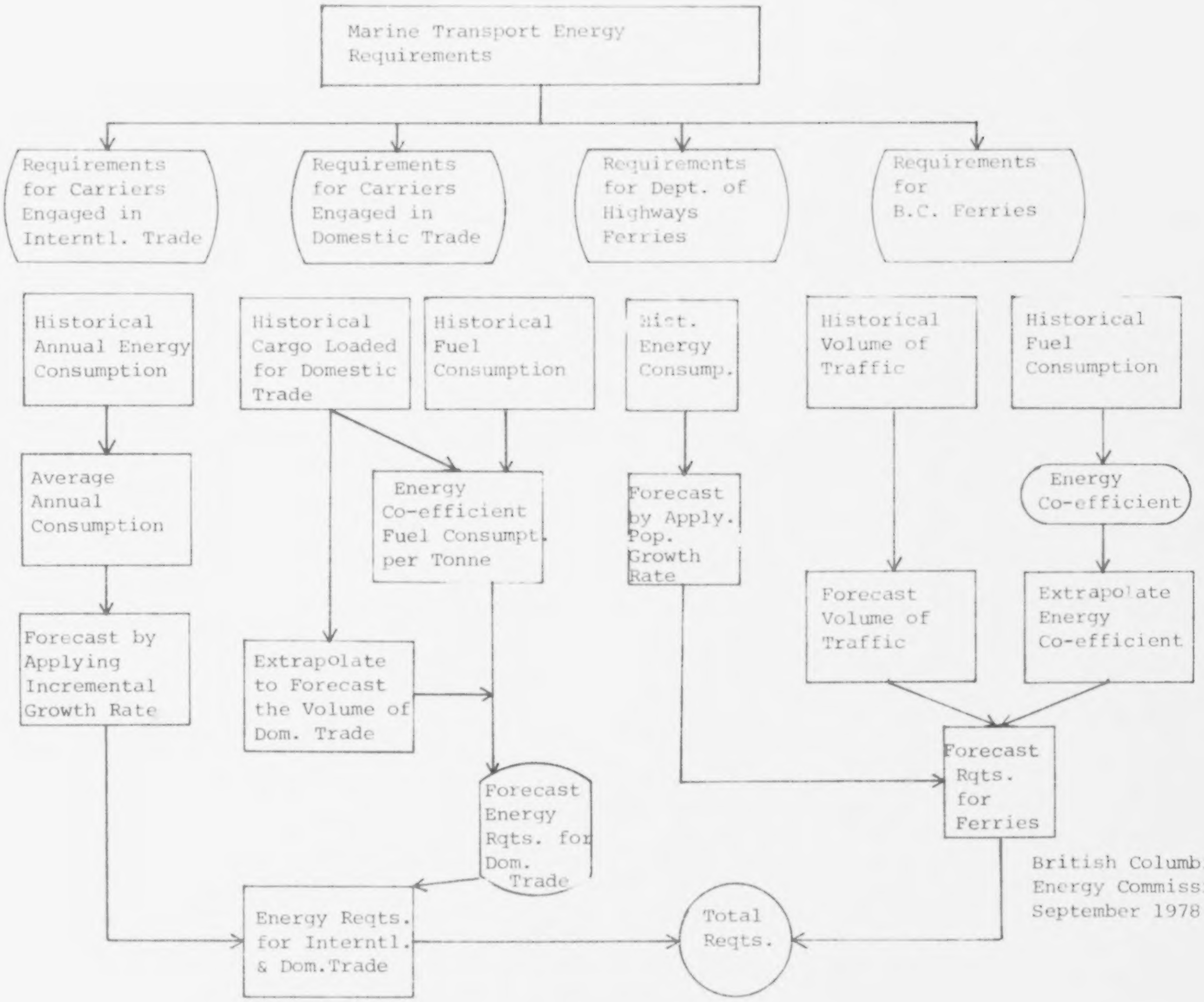
operating under the jurisdiction of the British Columbia Ministry of Highways. It should be noted that marine energy use is defined here as including all uses of fuel by commercial marine shipping companies. Any fuel used in marine transport by carriers that are not for hire would be included in the industrial sector. For instance, fuel consumed by an oil company for the shipment of its own goods in its own carriers would not be included in the transportation sector. One exception to this situation is the inclusion of all marine carriers operating as subsidiaries to railway companies. Figure 6.4 outlines the methodology employed for forecasting energy requirements in the marine transport sector.

Carriers Engaged in International and Domestic Trade

The total amount of international trade activity in British Columbia ports has been increasing for the last several years. Cargo loaded for inter- or intra-provincial trade, however, has been generally declining. In total, the amount of cargo loaded at British Columbia ports has followed a rather marked upward moving cyclical pattern from 1965 to 1976. The amount of export based cargo loaded in British Columbia depends not only on the economic climate in British Columbia and the rest of Canada but also on the economic health of trading partners in Japan, Europe and elsewhere.

FIGURE 6.4

FLOW CHART
MARINE TRANSPORT ENERGY FORECAST


Marine Transport Energy Requirements
Requirements for Carriers Engaged in Interntl. Trade
Requirements for Carriers Engaged in Domestic Trade
Requirements for Dept. of Highways Ferries
Requirements for B.C. Ferries
Historical Annual Energy Consumption
Historical Cargo Loaded for Domestic Trade
Historical Fuel Consumption
Hist. Energy Consump.
Historical Volume of Traffic
Historical Fuel Consumption
Average Annual Consumption
Energy Co-efficient Fuel Consumpt. per Tonne
Forecast by Apply. Pop. Growth Rate
Energy Co-efficient
Forecast by Applying Incremental Growth Rate
Extrapolate to Forecast the Volume of Dom. Trade
Forecast Volume of Traffic
Extrapolate Energy Co-efficient
Forecast Rqts. for Ferries
Forecast Energy Rqts. for Dom. Trade
Energy Reqts. for Interntl. & Dom.Trade
Total Reqts.

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Heavy fuel oil used in marine transport is consumed largely in the international movement of cargo. Table 6.10 lists cargo loaded for foreign ports and consumption of heavy fuel oil during the period 1965 to 1976. There is a noticeable downward trend in energy use per tonne loaded after 1967, from a high of 470 million joules per tonne that year to a low of 130 million joules per tonne in 1973. This trend reflects both increased loadings and decreased purchases of heavy fuel oil. Increasingly, freighters using west coast ports appear to be "topping up" on heavy fuel oil when in British Columbia, with relative fuel oil prices encouraging freighters to make their major purchases at such ports as Seattle, Portland and Los Angeles. The high level of use indicated in 1974, for example, resulted from temporary supply shortages experienced at these other ports, while in 1976, consumption jumped in response to low heavy fuel oil prices in the Vancouver area.

With the exception of 1974 and 1976, heavy fuel oil use has ranged from 4.462 to 6.167 quadrillion joules per year since 1970. The average for these five years is 5.030 quadrillion joules. This value has been employed as an estimate of annual heavy fuel oil consumption in the marine transport sector until

TABLE 6.10

HISTORICAL DATA ON DEEP-SEA MARINE TRADE ACTIVITY AND ENERGY COEFFICIENTS

	Cargo Loaded (to foreign countries) (tonnes)	Heavy Fuel Oil Consumption (Quadrillion Joules)	Energy Coefficient (million joules/ tonne)
1965	17,277,926	6.266	360
1966	18,627,236	7.751	420
1967	20,134,417	9.436	470
1968	22,108,897	5.918	290
1969	18,808,575	5.759	250
1970	24,542,383	5,067	210
1971	30,519,792	6.167	200
1972	31,920,967	4.462	140
1973	34,919,249	4.564	130
1974	32,593,240	7.875	240
1975	31,227,588	4.894	160
1976	33,375,746	7.138	210

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1982. After 1982 consumption increases by 20 percent in 1987 and by a further 10 percent in 1992, reflecting the prospect of higher loadings in response to possible expansion of Prince Rupert, Roberts Bank and other ports.

Table 6.11 details cargo loadings for domestic trade in the 1965 to 1976 period, and energy consumption in the marine transport sector excluding heavy fuel oil. While the resulting energy use coefficient appears to have been increasing over time, its value appears to have stabilized at approximately 850 million joules per tonne since 1974. This value has been used for forecasting purposes, due to the uncertainty of future fluctuations in this coefficient.

Domestic shipping activity is dependent upon such factors as strength of the coastal forest industry and level of general cargo handled. To forecast future levels of activity, domestic shipping has been disaggregated into three categories, as follows:

i) Wood Products - Tonnage of wood products moved in coastal trade compared to the total timber scaled in the B.C. coastal industry has varied widely from year to year, but during the past five years, the coefficient has averaged .71 tonnes loaded per cubic metre of timber scaled. This coefficient has been utilized for forecasting purposes. The volume of timber scaled has been forecasted to increase to 11.2 million cunits in 1982,

TABLE 6.11

HISTORICAL DATA ON DOMESTIC SHIPPING AND ENERGY COEFFICIENTS

	Cargo Loadings for Domestic Shipping	Marine Transport Sector Energy Consumption Excluding Heavy Fuel Oil	Energy Coefficients
	(tonnes)	(Quadrillion Joules)	(million joules/tonne
1965	16,113,324	6.131	380
1966	19,088,734	7.104	370
1967	18,327,755	7.550	410
1968	17,876,540	7.787	440
1969	19,078,942	7.902	410
1970	16,499,203	7.404	450
1971	13,405,138	7.781	580
1972	12,878,149	8.378	650
1973	13,531,981	8.478	630
1974	12,354,592	10,291	830
1975	9,715,410	8.151	840
1976	11,097,818	9.773	880

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after which time production growth rates decline in response to declining harvest levels on temporary tenures. Resulting tonnages are given in Table 6.12.

ii) Fuel - During the past seven years, fuel transported in the domestic shipping trade has averaged 20 percent of refined petroleum products consumed in the province. Tonnages moved in future are assumed to remain at 20 percent of total RPP requirements; resulting tonnages are given in Table 6.12.

iii) General Cargo - Loadings of general cargo have fluctuated on a year to year basis. In the absence of other projections, tonnage is assumed to grow at the rate of population growth from a 1976 base year. Resulting tonnages are given in Table 6.12.

Total domestic loadings for the forecast period are given in Table 6.12, together with resulting energy requirements. All energy requirements are in refined petroleum products.

B.C. Ferries Corporation and Ministry of Highways Ferries

The British Columbia Ferries and the Ministry of Highways Ferries account for most of the vehicular and passenger traffic travelling on various water routes on the Pacific coast and in the Interior. Approximately 60 percent of this traffic travels by B.C. Ferries and the remaining 40 percent is carried

TABLE 6.12

FORECASTED DOMESTIC SHIPPING LOADINGS AND ENERGY REQUIREMENTS

	Loadings (tonnes)				
	Wood Products	Refined Petr. Products	General Cargo	Total	Energy Requirements* (Quadrillion Joules)
1977	7,136,146	1,322,078	3,260,879	11,761,495	9.997
1978	7,329,554	1,370,779	3,303,271	12,046,546	10.240
1979	7,474,937	1,397,272	3,346,213	12,261,923	10,423
1980	7,625,409	1,424,416	3,389,714	12,483,606	10,611
1981	7,781,147	1,437,532	3,433,781	12,697,098	10,793
1982	7,942,336	1,455,195	3,478,419	12,921,170	10,983
1987	7,952,459	1,531,039	3,782,889	13,266,387	11,276
1992	8,130,491	1,653,247	4,035,254	13,818,992	11,746

* Based on 850 million joules per tonne loaded.

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by the Ministry of Highways Ferries.[7] Because of the larger size and longer routes, the total fuel consumption by B.C. Ferries is much larger than consumption by Highways ferries. In 1977 the B.C. Ferries accounted for 85 percent of the total fuel consumed by this mode of transportation.

The forecast of energy requirements for these ferries was formed on the basis of information received from the agencies in charge of their operation. In general the forecast demand for the B.C. Ferries' services was derived from the extrapolation of historical trends. The energy requirements forecast was then arrived at by applying the related trend in energy consumption to the forecast of ferry traffic. In the case of the Ministry of Highways Ferries, future energy requirements were projected to grow at the same rate as population growth over the forecast period.

Finally, combining the energy requirements forecast for ferries with the forecast for international and domestic carriers yields forecast total energy requirements for marine transportation. Table 6.13 contains the energy requirements for ferries and the total energy requirements forecast for marine transport.

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[7] *1976 Annual Report of the Ministry of Energy, Transport and Communications; 1976 Annual Report of the Ministry of Highways.*

TABLE 6.13

FORECAST ENERGY REQUIREMENTS
MARINE TRANSPORTATION SECTOR
(Quadrillion Joules)

	International Trade	Domestic Trade	Ministry of Highways and B.C. Ferries	Total Marine Transport
1977	5.030	9.997	3.727	18.754
1978	5.030	10.240	3.845	19.115
1979	5.030	10.423	3.960	19.413
1980	5.030	10.611	4.073	19.714
1981	5.030	10.793	4.177	20.000
1982	5.030	10.983	4.279	20,292
1987	6.036	11.276	4.920	22.232
1992	6.640	11.746	6.168	24.554

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IV. Rail Transport

Rail transport fuel consumption is primarily based on the use of diesel fuel and a modest amount of heavy fuel or crude oil. The three main rail companies operating in British Columbia are Canadian National Railway, Canadian Pacific Railway, and British Columbia Railway. Energy consumption by the railways has increased at an average annual rate of 5.4 percent over the period 1968 to 1976. Energy consumption for this period is shown in Table 6.14 by type of fuel consumed.

Table 6.14 also contains the annual values of total carload freight loaded in British Columbia over the historical period. There has been a high correlation between the total freight loaded and total fuel delivered to railways in British Columbia, given that locomotives moving bulk commodities such as grain and potash from the prairies to west coast ports are typically fuelled in Alberta. By employing simple linear regression techniques, an estimate was made of the relationship between these two factors[8] and this relationship was used to forecast future energy requirements for rail transport in the province. Figure 6.5 depicts the methodology used.

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[8] *The estimated linear relationship was found to be: Fuel consumed (10^{15} joules) = .3901 (10^6 tonnes of freight) + 1.7862 with an R^2 value of .956.*

TABLE 6.14

HISTORICAL ENERGY CONSUMPTION BY THE RAILWAY SECTOR AND TOTAL RAIL FREIGHT LOADED IN B.C.

	Fuel Consumed[1] (Quad. Joules)			Total Rail Freight Loaded in B.C.[2] (10^6 tonnes)
	Diesel	Crude Oil	Total	
1968	9.1152	-	9.1152	17.716
1969	8.9695	-	8.9695	18.762
1970	9.8693	-	9.8693	22.414
1971	11.8448	.0363	11.8811	25.756
1972	13.7452	.0605	13.8057	28.892
1973	13.6961	.0493	13.7454	30.995
1974	13.2929	.0083	13.3012	30.684
1975	13.7842	.0064	13.7906	30.329
1976	12.6383	1.2829	13.9212	31.464

1. Source: Statistics Canada, Railway Transport Part III, Catalogue 52-209
2. Source: Statistics Canada, Railway Freight Traffic, Catalogue 52-205

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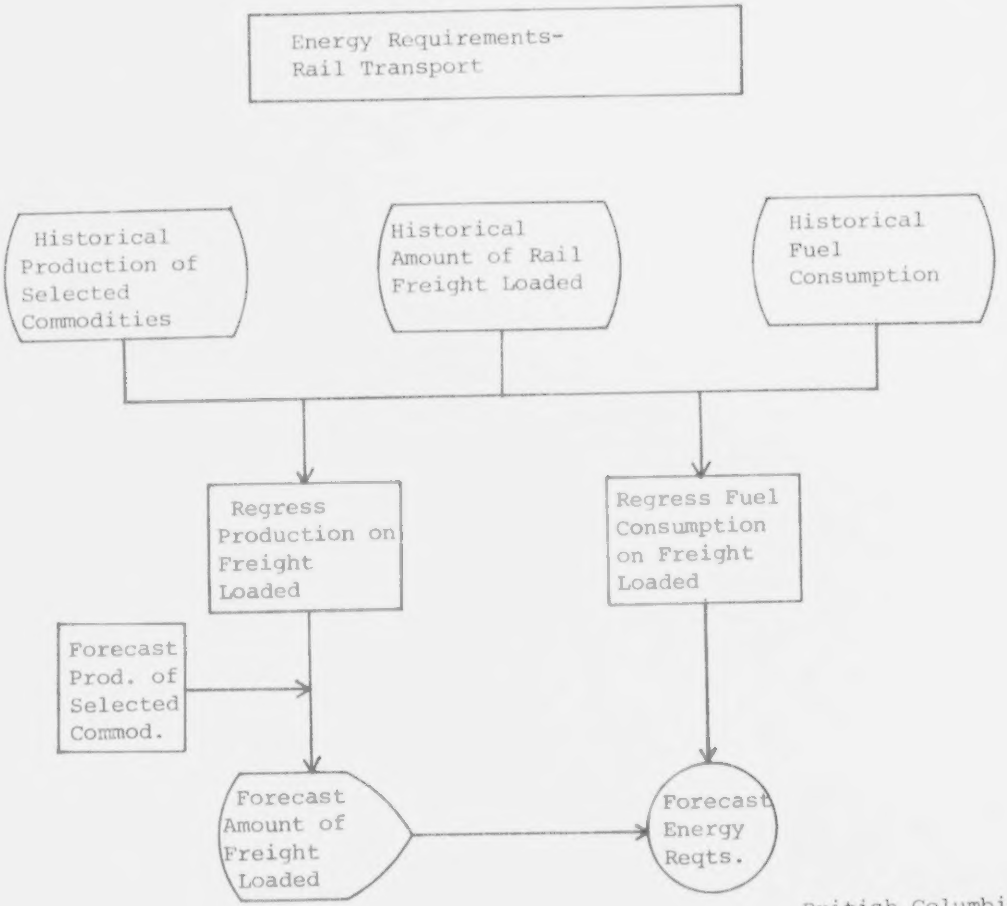
FIGURE 6.5

FLOW CHART
RAIL TRANSPORT ENERGY FORECAST


Energy Requirements-
Rail Transport
Historical Production of Selected Commodities
Historical Amount of Rail Freight Loaded
Historical Fuel Consumption
Regress Production on Freight Loaded
Regress Fuel Consumption on Freight Loaded
Forecast Prod. of Selected Commod.
Forecast Amount of Freight Loaded
Forecast Energy Reqts.

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The forecast of total carload freight loaded in British Columbia was also estimated using regression analysis. The major sources of freight loaded in the province include shipments of lumber, pulp and paper, coal, copper, lead and zinc which together account for over 70 percent of the total freight loaded on railways. Since a forecast of rail shipments of these products is not available, total production of these main products was used as the explanatory variable in estimating future total rail freight shipments.[9] Although rail or port bottlenecks could constrain growth of total loadings in British Columbia in the short term, this impact is expected to be of minor consequence. Shipments of bulk commodities originating on the prairies, on the other hand, could be affected by limitations of rail or port capacity. The forecast of total rail freight loaded in British Columbia is shown in Table 6.15.

Energy consumption in the rail transport industry has been predominantly diesel with some use of heavy fuel oil and crude oil. In 1976 the fuel shares were 91.0 percent diesel and 9.0 percent other. According to industry representatives, the amount of heavy fuel oil and crude oil used is not expected

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[9] *The linear relationship estimated in this analysis is: Total rail freight (10^6 tonnes) = 1.3302 (10^6 tonnes of production of selected products) + 3.2504; $R^2 = .976$.*

TABLE 6.15

FORECAST OF TOTAL RAIL FREIGHT
(Million Tonnes)

	Production of Selected Products in B.C.[1]	Total Rail Freight Loaded[2]
Historical Data		
1967	10.738	17.062
1968	11.507	17.716
1969	11.848	18.763
1970	13.870	22.414
1971	16.258	25.756
1972	18.624	28.894
1973	21.321	30.995
1974	20.719	30.684
1975	19.441	30.329
1976	22.244	31.464
Forecast		
1977	23.322	34.273
1978	24.958	36.450
1979	25.879	37.675
1980	26.820	38.926
1981	27.883	40.340
1982	28.990	41.813
1987	38.912	55.011
1992	44.339	62.230

1. See the sections on the related industrial sectors. Selected products include lumber, pulp and paper, coal, copper, lead and zinc.

2. See Table 6.13

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to increase in the future. Therefore, any growth in energy consumption is assumed to be captured by diesel fuel. No allowance was made for electrification of any of the railway systems as it appears unlikely that this will occur before the end of the forecast period.

Table 6.16 contains the forecast of energy requirements for the rail transport sector in British Columbia.

TABLE 6.16

FORECAST FUEL CONSUMPTION IN RAILWAY SECTOR

(Quadrillion Joules)

	Total Energy	Diesel	Crude Oil
1977	15.156	13.873	1.283
1978	16.005	14.722	1.283
1979	16.483	15.200	1.283
1980	16.971	15.688	1.283
1981	17.523	16.240	1.283
1982	18.097	16.814	1.283
1987	23.246	21.963	1.283
1992	26.062	24.779	1.283

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CHAPTER 7

OTHER REQUIREMENTS

I. Asphalt, Lubricating Oils and Greases

Table 7.1 contains the historical net sales of asphalt, lubricating oils and greases over the period 1965 to 1976. Net sales of asphalt increased at an average annual rate of 5.1 percent over this period. Since 1972, however, total sales have been gradually declining. Since approximately 80 percent of asphalt sales are for paving, these figures are a reflection of highway construction activity.

Net sales of lubricating oils and greases have increased at an average annual rate of 3.8 percent over the historical period with growth in these sales slowing to only 1.6 percent per year from 1971 to 1976.

The consumption of these products, being a minor proportion of total refined petroleum products (about 4 percent by volume in 1976), does not warrant detailed analysis. It was therefore assumed that sales of both products will continue to grow at the eleven year historical rate until the end of the forecast period. The relatively high growth rate in asphalt sales, as compared to recent years experience, is generally consistent with increased activity in road

TABLE 7.1

HISTORICAL NET SALES OF ASPHALT, LUBRICATING OIL, AND GREASES

	Net sales of:	
	Asphalts	Lubricating oils and greases
	(000 m^3)	
1965	156.8	70.9
1966	138.5	73.3
1967	169.5	76.2
1968	201.1	79.8
1969	222.4	87.0
1970	228.6	86.5
1971	230.9	98.9
1972	317.7	104.6
1973	306.9	114.2
1974	310.2	108.9
1975	274.1	100.3
1976	270.3	106.8

Source: Statistics Canada, Refined Petroleum Products Volume II, Catalogue 45-208.

construction associated with improving the infra structure to facilitate northern development.

The forecasts of requirements for asphalt, lubricating oils and greases are contained in Table 7.2

II. Petrochemical Feedstock Requirements

The major petrochemical feedstock requirement in the province at the present time is that of the Cominco ammonia plant at Trail which consumed approximately 43.9 million cubic metres of natural gas in 1977. The sulphurous gases produced by the Cominco metallurgical operations cannot be emitted into the atmosphere and are combined with the ammonia to produce fertilizers. Expansion of the metallurgical output will not necessarily bring an increased petrochemical feedstock requirement, however, as production of fertilizer is no longer as attractive as when the ammonia plant was built. It is more likely that ammonia will be imported from Alberta or some means employed to dispose of the by-product gases. It is also possible that the ammonia plant at Trail will be closed down completely in favour of importing all ammonia requirements from Alberta, if the price of natural gas in this province experiences a substantial increase. It has been assumed that this plant will not close before the end of the forecast period.

TABLE 7.2

FORECAST NET SALES OF ASPHALT, LUBRICATING OILS AND GREASES

	Forecast Net Sales of:	
	Asphalts	Lubricating Oils and greases
	(000 m^3)	
1977	284.1	110.9
1978	298.6	115.1
1979	313.8	119.4
1980	329.8	124.0
1981	346.6	128.7
1982	364.3	133.6
1987	467.2	161.0
1992	599.2	194.0

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The only other petrochemical feedstock requirement that warrants specific mention is the Dow Chemical phenol plant at Ladner. This plant currently consumes approximately 62,000 m^3 of toluene per year. Phenol is used exclusively in the production of plywood adhesives, therefore, the forecast of requirements for toluene is related to the forecast of plywood production.

No other petrochemical developments are expected to materialize over the forecast period. Some of the potential plants that may develop further into the future include plants to produce methanol, ethylene, ethyl benzene and xylene.

The forecast of petrochemical feedstock requirements is shown in Table 7.3.

III. Requirements for Thermal Generation

B.C. Hydro has approximately 1,292 MW of thermal electric generation capacity. The majority of this capacity is at the Burrard station in the Lower Mainland. This plant has been fired principally by natural gas although oil has been used as a standby fuel, usually consumed in small amounts during the winter for peaking service when the maximum day gas supply was insufficient to operate the plant at the required capacity. Oil storage at the Burrard plant is

TABLE 7.3

FORECAST PETROCHEMICAL FEEDSTOCK REQUIREMENTS
(Quadrillion Joules)

	Natural Gas	Toluene[1]	Total
1977	1.64	1.86	3.50
1978	1.64	1.92	3.56
1979	1.64	1.97	3.61
1980	1.64	2.03	3.67
1981	1.64	2.09	3.73
1982	1.64	2.15	3.79
1987	1.64	2.37	4.01
1992	1.64	2.62	4.26

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[1] *Toluene has a heat content of 29.962 GJ/*m^2.

capable of supplying only eight days' fuel to the boilers at 100 percent capacity.

Due to environmental concerns, B. C. Hydro does not have permission to burn either gas or oil at the Burrard plant at this time. Some experimentation have been done with burning different sulphur content oils at the plant. The future of Burrard is highly uncertain at this time, therefore no allowance is made in this forecast for natural gas or oil to fire the Burrard generating station.

The Province's industrial sector has approximately 429 MW of thermal generation capacity. The fuel requirement for electricity generation by this group is included in the requirements of the industrial sector under the appropriate industry and type of fuel used.

CHAPTER 8

THE POTENTIAL FOR COAL USE IN BRITISH COLUMBIA

I. Introduction

In the Energy Commission's 1976 Energy Outlook Forecast, it was recommended that a comprehensive energy plan should emphasize greater energy self-sufficiency for the province. While the outlook for natural gas supply in the province is optimistic, British Columbia imports over 70 percent of its total oil requirements, and it is expected that by early in the twenty-first century this dependency will become almost total.

Coal is one of the most abundant energy resources in the province with current estimated reserves containing a heat content of 114,660 quadrillion joules.[1] This compares to the estimated heat content in the province's natural gas reserves of 7,757 quadrillion joules in 1977. In other words, on an energy equivalent basis, the province has over fourteen times more coal than natural gas. Coal, however, accounts for less than two percent of total industrial energy consumption.

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[1] *This number only includes the 4694 million tonnes of coal reserves; there is a further estimated resource of coal which is thought to be between 99770 and 272100 million tonnes. The average heat content of the coal is estimated at 24,428 gigajoules per tonne.*

Eventually, market forces should dictate increased utilization of the more abundant coal reserves instead of higher priced and scarcer resources of oil and natural gas. The speed at which this trend develops will depend to a great degree on whether the government adopts policies to encourage the use of coal as an alternate energy supply.

Coal can be used as fuel in boilers to produce steam for industrial processes or to drive generating turbines. It is used directly in steel production. In other areas coal was, and in some cases still is, used as the fuel which provides heat in the drying kilns for the manufacture of cement.

A more indirect use of coal is its conversion to synthetic natural gas or synthetic liquid fuels. Although the technology for coal conversion has existed for some time, it has only recently become economically viable. This is particularly true of coal gasification. Less is known about the economics of coal liquefaction, but it may be important in the future.

The potential for coal to displace oil and natural gas in the various segments of the industrial sector is discussed in the following sections. An attempt is made to identify the potential for coal usage in this market, based upon both technical and economic considerations. The aggregate forecast of coal consumption is shown at the end of the Chapter, along with the implied changes in industrial fuel share of natural gas and oil as shown in Chapter 5. The potential use of coal in gasification and liquefaction is not included.

II. The Forest Sector

From a technical standpoint the greatest potential for coal in the forest sector is as a fuel for steam boilers. These boilers produce steam either for process use (for example, paper dryers) or for the production of electricity using steam turbines. Fuel used to fire lime kilns is not generally amenable to substitution by coal due to problems with contamination of the lime produced.

Although coal is used extensively as a fuel for boilers in the eastern Canadian kraft pulp industry, mills in British Columbia have not been designed to use this particular fuel in their boilers. Since modifying existing boilers to fire coal would necessitate major capital costs, prospects for utilization of coal appear brightest with respect to new boiler installations. It has been assumed in this report, however, that hog fuel and waste liquor would be used to meet energy requirements in new mills, rather than other fuels. So long as hog fuel is valued at zero cost, or assigned a negative cost to reflect costs incurred in landfill or other disposal, coal will not be the preferred fuel in this application.[2] For this reason, significant conversion to coal during the forecast period has not been assumed in this forecast.

III. Minerals Sectors

1. Mining - Metals

The major end uses of energy in the metal-mining sector[3] are: in the mining process (shovels, carriers, etc.); in the crusher and flotation stages of the concentrator; in the supply of ventilation air; in the drying of concentrate and in electricity generation in some of the more remote areas. Of these, the last three could potentially be supplied by coal.

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[2] *See, for example, British Columbia Wood Waste Energy Co-ordinating Committee Hog Fuel Co-generation Study: Quesnel, British Columbia 1978 and InterGroup Consulting Economists Ltd., Liquid Fuels from Renewable Resources: Feasibility Study, Volume C, 1978.*

[3] *The metal mines referred to in this section include only lead, zinc, copper and molybdenum.*

The degree to which coal will infiltrate the mining sector energy market over the forecast period will depend on both the supply and the relative price of this fuel. In a recent Commission staff study, it was forecast that by 1980 the real price differential between coal and natural gas would be more than $1.00 per gigajoule and by 1987 more than $2.00 per gigajoule. It was also assumed that the coal supply will develop in pace with demand.

In 1975 the Energy Commission did a survey of the metal mines in British Columbia. In response to a question concerning the use of coal as an energy source many mines responded that there is a future for coal as an energy source when it becomes cheaper per unit of energy than existing sources. One company suggested that this price differential would have to be in the neighbourhood of $1.00 per gigajoule to seriously consider the use of coal in place of natural gas in their operations.

In light of the foregoing, it is expected that some time around 1980 the use of coal as an energy source in the province's mining sector should increase. For the purpose of showing the potential for coal as it relates to this forecast of energy requirements, it is assumed that from 1980 on all new metal mines will use coal in place of natural gas and fuel oil for supplying ventilation air, heating, and drying the concentrate. On the basis of the 1975 survey, it was estimated that on the average 25 percent of total energy consumed by these mines is used for these purposes. It is further assumed that by 1987, existing mines will convert their heating and drying systems to coal fired boilers.

Table 8.1 contains the forecast of energy requirements for metal mines (copper, lead-zinc, and molybdenum) incorporating the potential for coal as an energy source.

Coal Mines

There are two major metallurgical coal mining companies in British Columbia. After mining, coal must be washed, leaving it with a moisture content of about 16-20 percent. It is then passed through drying columns where the moisture content is reduced to eight percent. For both producers, the heat required for drying the coal is currently obtained by burning natural gas. This energy requirement could be supplied by coal.

Metallurgical coal mines produce middlings and tailings coal as a by-product. Since this coal source is produced on site the price differential between it and natural gas will be even greater than that discussed in the preceding section.

TABLE 8.1

FORECAST ENERGY REQUIREMENTS
METAL MINING-WITH COAL USE
(Quadrillion Joules)

	Electricity*	Natural Gas	R.P.P.	L.P.G.	Coal	Total
1977	6.799	.607	4.637	.232	-	12.275
1978	8.016	.655	5.532	.277	-	14.480
1979	7.390	.643	5.017	.250	-	13.300
1980	7.135	.622	4.363	.200	.252	12.572
1981	7.610	.622	4.511	.200	.426	13.369
1982	8.193	.622	4.711	.200	.365	14.091
1987	10.679	.156	3.616	.006	4.130	18.587
1992	12.965	.156	4.346	.003	4.808	22.278

* Includes .06 quadrillion joules self-generated hydro electricity.

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Although some technical problems associated with using this coal remain to be solved, it is assumed that all heat requirements for coal drying are supplied by coal after 1980. The resulting energy requirements forecast is shown in Table 8.2.

Other Minerals Mining

This group of mining industries is comprised of widely varying types of mines, and it is therefore difficult to make any general comments regarding the potential for coal in this sector. Many of the mines included in this group (such as precious metal mines) are small and tend to be labour rather than energy intensive. Thus, no allowance is made for use of coal as an energy source in "other minerals" mining.

2. Non-Metallic Minerals

Cement

Cement is made from a mixture of about 80 percent carbonate of lime (e.g. limestone), and 20 percent clay. After mixing, the materials are finely ground by a wet or dry process and then calcined[4] in kilns to a clinker. When cool this clinker is ground to a fine powder, during which gypsum is added to regulate the setting characteristics of the cement. The calcining

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[4] *Calcination is a process in which calcium oxide and silicon oxides are chemically transformed into calcium silicates.*

TABLE 8.2

FORECAST ENERGY CONSUMPTION IN THE COAL MINING INDUSTRY SHOWING POTENTIAL FOR COAL AS A HEAT SOURCE

(Quadrillion Joules)

	Electricity	Natural Gas	R.P.P.	Coal	Total
1977	.804	2.264	1.480	-	4.548
1978	.851	2.333	1.568	-	4.752
1979	.894	2.402	1.648	-	4.944
1980	.939	2.463	1.729	-	5.131
1981	.984	-	1.815	2.780	5.579
1982	1.034	-	1.906	2.824	5.764
1987	1.666	-	3.070	4.568	9.304
1992	1.930	-	3.561	4.829	10.320

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process takes place at very high temperatures (up to 1425°C) in kilns and it is the heating of the kilns for which natural gas is used in the cement industry.

The natural gas used by this industry can potentially be substituted by coal. Some of the ash produced by burning coal in the kilns is absorbed by the clinker and alters the chemical composition of the product. A problem arises with product uniformity when the coal used has a wide variation of characteristics. Burning coal instead of natural gas in the kilns also results in additional emissions in the form of ash particle. Both of these problems with coal fired kilns can be overcome with some added expense. Most cement plants in the Pacific Northwest area of the United States have already converted to coal.

In a recent Energy Commission staff paper on coal potential in the cement industry, it was found that under "best guess" assumptions it would be economically justifiable for the cement plants at Tilbury Island and Richmond to convert from gas-fired kilns between 1982 and 1986. The third plant at Kamloops is assumed to convert in 1991. Table 8.3 shows the effect of coal conversion in these plants on the forecast of energy requirements for the cement industry.

TABLE 8.3

FORECAST ENERGY REQUIREMENTS
CEMENT MANUFACTURERS, WITH COAL CONVERSION

(Quadrillion Joules)

	Natural Gas	R.P.P.	Electricity	Coal	Total
1977	5.900	3.310	.645	-	9.855
1978	7.366	1.660	.705	-	9.731
1979	7.366	.223	.686	-	8.275
1980	7.406	.226	.691	-	8.323
1981	7.522	.235	.706	-	8.463
1982	7.562	.238	.711	-	8.511
1987	1.414	.237	.682	6.370	8.703
1992	-	.237	.741	9.103	10.081

Other Non-Metallic Minerals

The second largest user of energy in the non-metallic minerals group is the glass manufacturing industry. In glass manufacturing, natural gas is burned in furnaces for the purpose of melting the raw materials which are transformed into glass. It is also used for annealing, a process in which glass containers are heated and cooled slowly in order to relieve stresses that have been produced during the casting process. In British Columbia, this industry uses natural gas as a primary fuel with oil as a standby fuel. The only present alternative to natural gas/oil in the glass industry is electricity. Substitution of natural gas by solid fuels is not considered feasible at the present time.

Other industries in this sector are generally of a small scale. Therefore, it is assumed that there will be no conversion to use of coal as an energy source by these industries.

3. Primary Metals

The largest energy consuming activities in the primary metal sector in British Columbia include the smelting and refining of lead and zinc (Cominco), aluminum (Alcan) and copper (Afton). There are also smaller operations involved with metal rolling, casting and extruding. The major potential for coal use as an energy source is to replace the natural gas consumed in boilers, roasters and furnaces.

Many of the operations presently consuming natural gas for the above mentioned purposes are too small to economically convert to coal. Also, in some areas of the province (such as the north coast), the relative price of coal versus natural gas is not forecast to be as attractive as in other areas of the province,due to the high transportation costs involved. To account for these factors, it was estimated that approximately 42 percent of the forecast natural gas requirement for 1987 and 1992 could potentially be converted to coal consumption. The resulting energy requirements forecast including coal conversion is shown in Table 8.4.

IV. Chemicals

In the manufacture of industrial chemicals (such as caustic soda, chlorine gas, phenol and benzoic acid), natural gas is generally used to generate process heat. In this application there is a potential for substitution by coal. In the Hooker Chemicals plant, however, natural gas is burned in conjunction with the hydrogen produced in the electrolytic process. About 75 percent of the hydrogen so produced is used as boiler fuel.

TABLE 8.4

PRIMARY METALS SECTOR

Energy Requirements Forecast with Coal Conversion

(Quadrillion Joules)

	Total Energy	Purchased Elec.	Natural Gas	L.P.G.	R.P.P.	Coal & Coke	Self-Gen. Elec.
1977	44.088	5.547	5.339	.009	.362	6.510	26.315
1978	44.372	5.583	5.666	.009	.368	6.648	26.185
1979	45.393	5.712	5.673	.009	.366	6.731	26.902
1980	46.372	5.835	5.726	.009	.366	6.814	27.622
1981	47.322	5.954	5.811	.010	.364	7.201	27.982
1982	48.870	6.149	5.790	.010	.364	7.035	29.422
1987	59.376	7.139	4.823	.011	.431	12.148	34.824
1992	85.166	10.638	4.830	.012	.459	31.303	37.834

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Coal cannot be burnt with the hydrogen and thus would require a separate hydrogen-burning boiler. For all practical purposes, therefore, it is assumed that the natural gas consumed by this plant is not amenable to substitution by coal.

Table 8.5 contains the forecast of energy requirements in the chemicals and chemicals products industries, including some allowance for use of coal as an energy source in the manufacture of industrial chemicals.

V. Other Industries

Of the remaining industries, the only major users of energy are the oil refineries. Refinery process heat is supplied either directly from combustion of the heating fuel or from steam produced by such combustion. Were coal to be used to supply process heat, it would need to be supplied in the form of steam for two reasons: because of the large number of different processes requiring heat, and because of the requirement for control of the level of heat input. It is unlikely that such a method of providing process heat would be economic relative to the use of either natural gas or petroleum products, in light of the high associated costs of such a system and the inherent inefficiency of steam heat relative to combustion heat. Therefore, it is highly improbable that coal will replace

TABLE 8.5

FORECAST TOTAL ENERGY REQUIREMENTS IN CHEMICAL AND CHEMICAL PRODUCTS INDUSTRY

(Quadrillion Joules)

Year	Natural Gas	Electricity	R.P.P.	Coal	Total
1977	3.66	4.06	.75	-	8.47
1978	4.42	4.93	.89	-	10.24
1979	4.57	5.10	.91	-	10.58
1980	4.72	5.26	.95	-	10.93
1981	4.87	5.43	.99	-	11.29
1982	5.03	5.60	1.04	-	11.67
1987	1.57	5.98	1.14	4.24	12.93
1992	1.82	6.72	1.31	4.74	14.59

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natural gas or petroleum products to supply heat to the oil refining process.

The remaining industries are generally of too small a scale to make the use of coal economic due to the extra handling and storage involved when coal is substituted for natural gas or petroleum products.

VI. Summary

Table 8.6 summarizes the potential for coal as an energy source in the industrial sector. An attempt has been made to identify those principal areas where coal conversion is technically and economically feasible, although it must be recognized that, due to factors other than those considered here, some usages of coal identified as potential may not, in fact, be feasible.

As can be seen by comparing Tables 8.6 and 5.2, the use of coal as discussed in this Chapter would increase coal's share of total industrial energy consumption in 1992 from 4.7 percent (under a no conversion scenario) to 9.3 percent and reduce the industrial energy share of natural gas from 15.7 percent to 12.1 percent and of petroleum products from 16.4 percent to 15.8 percent. Under the high growth forecast, there would be a slightly greater potential for coal in the

TABLE 8.6

FORECAST ENERGY REQUIREMENTS
TOTAL INDUSTRIAL SECTOR SHOWING COAL POTENTIAL
(Quadrillion Joules)

	Natural Gas	R.P.P.	Purch. Elec.	L.P.G.	Coal	Hog Waste Fuel/Liquors	Self-Gen Elec.Hydro	Total
1977	64.64	80.29	44.50	2.04	6.52	150.98	28.73	277.70
1978	69.55	84.53	48.16	2.14	6.66	151.42	28.60	391.07
1979	69.73	85.15	48.85	2.17	6.74	157.34	29.31	399.29
1980	73.50	86.15	49.58	2.15	7.07	161.89	30.03	410.37
1981	73.57	84.37	51.48	2.21	10.41	170.52	30.39	422.95
1982	77.89	84.93	53.64	2.26	10.23	175.32	31.83	436.10
1987	64.01	86.60	63.85	2.17	31.47	221.50	37.17	506.77
1992	71.19	93.03	74.98	2.45	54.80	253.07	40.18	589.71

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mining sector. This potential has not been included since it does not significantly change the results shown in Table 8.6.

Coal in a converted form (either gasified or liquified) also has the potential to capture part of the industrial energy market at the expense of natural gas and petroleum products. The extent of this potential is currently under study as it applies to British Columbia.

B.C. Hydro is studying the development of thermal electric generation from the coal deposits at Hat Creek and other areas in the province. The timing of such a development will depend on the electricity load growth and the capability of existing generating capacity (including the new construction at Revelstoke) to meet this load growth.

CHAPTER 9

NON-CONVENTIONAL ENERGY SOURCES

I. Introduction

Although the ultimate potential for non-conventional sources of energy in British Columbia is considerable, no allowance has been made in this forecast for their use during the next 15 years. By 1992 some non-conventional energy sources will undoubtedly be in use, but because the timing and feasibility of new projects is still uncertain, any estimates of capture rates for these sources by that date would essentially be arbitrary.

This chapter briefly evaluates those non-conventional energy alternatives which demonstrate the greatest potential for use in British Columbia by 1992 and after. Included in this evaluation are solar energy systems, district heating systems based on geothermal heat or municipal refuse, wind energy, tidal energy and biomass. These non-conventional energy sources can generally be characterized as "soft" energy systems relying on decentralized renewable energy flows;[1] some large-scale centralized and capital-intensive projects have however, been proposed, for example, for solar energy and for biomass. Excluded from consideration in this chapter are the use of coal which is examined in Chapter 8, and the use of forestry wood waste for boiler fuel, which is also included in the forecast.

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[1] *Amory Lovins "Exploring Energy-Efficient Futures for Canada"* Conserver Society Notes *Volume 1, Number 4 (May-June 1976).*

II. Solar Energy

Direct solar energy systems can be used for low temperature space and water heating, thermal electric generation and photovoltaic electric generation. The essential problem in all such systems is that solar energy is a very low density form of energy, leading to the need for large collector surfaces. Secondly, the resource is not continuously available, requiring either that storage systems be added to meet energy requirements overnight and during periods of low solar radiation intensity, or else that conventional back-up systems be provided. As a consequence solar energy systems tend to have much higher capital costs than conventional heating systems for example, but very low operating costs. The amortization rate on capital will essentially determine whether a solar energy system is cost-effective in meeting heating and/or cooling requirements.

Residential solar heating has been quite feasible technically for many years. The essential components of an active residential system consist of a collector and a storage facility. Heat trapped by the collector is stored in hot water tank, hot rocks or, more recently, in a fusable salt. Distribution of heat through the house may be by conventional forced air or water radiators. In British Columbia, a supplementary heating system is required unless exceptional insulation or storage levels have been used.

Passive solar heating uses no forced circulation of air or water but relies on designs which take advantage mainly of heat gains through south windows. Some designs use natural circulation and storage but the thermal design of the building is critical and many 'passive solar homes' use more energy than conventional house designs.

Large scale solar generation systems using focused concentrators are receiving the attention of researchers but no economically practical plant has evolved. In one design, collectors over a large area follow the sun and focus on a fixed heat absorption area. Storage tanks then power a conventional steam generator set. Photovoltaic cells can be used to generate electricity directly instead of using the intermediate heat medium. At present the cost of the cells is prohibitively high, especially in the light of their low efficiency.

Probably the most immediate potential for residential solar energy applications in British Columbia lies in hot water heating. Improved technology, combined with lower capital costs through packaged units,could ultimately allow for penetration into residential, and possibly commercial, space heating and cooling markets. Widespread use of solar energy systems in industry is not foreseen.[2]

III. Geothermal Energy

Another alternate energy source concerns the use of geothermal heat for district heat or electric generation. This heat is derived from subterranean reservoirs of heat in the form of steam, hot water or hot dry rocks. In Canada, British Columbia contains the only potential area for steam or hot water, in the cordillera. The sedimentary basin of the prairies contains warm water and hot rocks, and this extends into the north east corner of the province.

Steam and hot water reservoirs can be tapped to drive turbines (by flashing to steam if necessary), while lower temperature water reservoirs may be suitable for use in space heating through direct circulation. District heating through direct circulation of hot water requires the geothermal reservoir to be close to urban areas to make such a system technically and economically viable, while geothermal electric generation requires a higher temperature reservoir. There are possible sites in B.C. but much more exploration is required to further define their probable potential.

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[2] *The National Research Council has recently estimated that only 2 percent of Canadian energy needs will be met by solar energy within 40 years. See* *Oilweek* *(September 25, 1978).*

British Columbia Hydro has commissioned a detailed study of the Meager Mountain area as a geothermal source.

IV. Wind Energy

Harnessing wind energy using windmills and electricity generators is quite feasible. British Columbia's coastal areas appear to have good potential for wind driven generators. In favourable locations wind energy may be a useful supplement to overall energy demand if scaled up units prove economic; primary constraints are high capital cost for facilities and electricity output which does not match the load curve.

In remote areas, pure wind systems would require battery storage facilities. For this reason hybrid wind/diesel systems may be more economic in such locations.

V. Tidal and Wave Energy

Use of tidal energy has long been proposed as an energy alternative. A tidal basin is necessary to harness this energy and the potential of a site is determined mainly from the area of the basin and the tidal amplitude. The force of the tide both entering and leaving the basin is used to power generators.

Another alternative is to use wave absorbing machines. In British Columbia there are numerous suitable sites but the technology to put them to efficient use has not yet been developed.

Tidal and wave power potential have not been studied extensively in British Columbia. Studies underway on Fundy Bay tidal power in the Maritimes, where electricity costs from thermal sources are substantially higher than in British Columbia, may provide some indication of the economic potential for this source of energy in British Columbia.

VI. Biomass Energy

Biomass energy is already used extensively in British Columbia in the forest industry, in the form of hog fuel and waste liquors to fire boilers for process steam and electricity generation. In 1976, it is estimated that hog fuel and waste liquors accounted for approximately 20 percent of all useful energy used in the province, once allowance has been made for losses in conversion. Additional hog fuel boilers are now in the planning stages.

Hog fuel, other mill residues and logging residues can, however, be put to uses other than boiler fuel, particularly in the production of liquid alcohols such as methanol. The United States, New Zealand, Sweden and Brazil have already embarked on or are considering liquid fuel programs designed to reduce dependency in the road transport sector on conventional petroleum products, i.e. motor gasoline and diesel fuel oil. Preliminary studies in Canada suggest that British Columbia may be the source of supply for one-third to one-half of the forest biomass potential in Canada;[3] this potential includes not only forest wastes and wood from decadent stands, but also wood from boimass plantations in the longer term.

A source of boimass energy in urban areas is municipal refuse, for district heating purposes and/or thermal electric generation. District heating systems are in wide use in some countries, for example, Sweden, while garbage is being burned in some North American cities for raising of steam and generation of electricity. Costs of retrofit and separator processes to handle garbage are constraints to development; for district heating, lack of firm industrial loads for steam may act as an additional barrier to use.

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[3] *InterGroup Consulting Economists Ltd., Liquid Fuels from Renewable Resources: Feasibility Study, Volume C. (March 1978).*

VII. Summary

Non-conventional energy sources offer some potential as forms of commercial energy by the end of the forecast period in 1992, but the extent of penetration into energy markets is difficult to assess at this stage. The British Columbia Energy Commission has initiated its own series of studies on renewable energy alternatives, starting with solar, geothermal and wind energy. Results of these studies should provide additional insight into the potential for non-conventional energy sources in the province.

CHAPTER 10

TOTAL ENERGY REQUIREMENTS

Tables 10.1 through to 10.5 summarize the forecast of energy requirements developed in Chapters 3 through 8. Tables 10.1 and 10.2 contain the best estimate and high forecasts of energy requirements by consuming sector respectively. Tables 10.3, 10.4, and 10.5 contain the forecast of energy requirements by fuel type according to the moderate, high and coal conversion scenarios, respectively.

The high forecast includes the residential forecast, the moderate conservation commercial forecast, the high growth industrial forecast, the no conservation transportation forecast and other requirements. The best estimate forecast includes residential requirements, high conservation commercial requirements, best estimate industrial requirements, conservation transportation requirements and other requirements. The coal potential scenario substitutes the findings of Chapter 8 for the best estimate industrial forecast.

The growth rate implied by the best estimate total energy forecast is 2.5 percent per annum over the fifteen year period to 1992; while under the high total energy forecast, the implied annual growth rate is 2.8 percent.

From Tables 10.1 and 10.2, it can be seen that the industrial sector is increasing its share of total energy consumption at the expense of the residential, commercial and transportation sectors. This is primarily a result of lower population growth and new building standards in the residential and commercial sectors, plus improved motor vehicle fuel economy in the transportation sector.

Since planning for adequate energy supplies requires long lead times, it is appropriate to include some allowance in a load growth forecast for the attachment of unforeseen loads. In the case of electricity, an explicit allowance of 300 megawatts (or 9.5 quadrillion joules at a capacity factor of 100 percent) has been made in 100 megawatt intervals in 1982, 1987 and 1992.

The same energy-equivalent allowance is made in natural gas requirements for unforeseen developments in the industrial sector. An allowance of this magnitude, for example, is sufficient to supply the energy requirements of two new pulp complexes or other major industrial developments.

Under the best estimate scenario, four fuels that are expected to experience any significant change in their market shares of total energy requirements are electricity, coal, hog fuel, and refined petroleum products. The shares of

TABLE 10.1

FORECAST TOTAL ENERGY REQUIREMENTS BY CONSUMING SECTOR

(Quadrillion Joules)

(Best Estimate Forecast)

	Residential	Commercial	Industrial*	Transportation	Total
1977	116.91	93.23	395.35	189.02	794.51
1978	119.30	94.47	409.51	196.42	819.70
1979	120.99	95.82	418.42	201.68	836.91
1980	122.56	96.13	430.26	206.77	855.72
1981	124.20	98.85	443.40	211.24	877.69
1982	125.51	101.68	463.97	214.33	905.49
1987	132.45	114.62	543.61	226.55	1,107.23
1992	139.10	123.15	638.83	247.11	1,148.19

* Includes petrochemical feedstocks, asphalt, lubricating oil and greases, and unforeseen requirements.

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TABLE 10.2

FORECAST TOTAL ENERGY REQUIREMENTS BY CONSUMING SECTOR

(Quadrillion joules)

(High Forecast)

	Residential	Commercial	Industrial*	Transportation	Total
1977	116.91	93.23	395.35	189.02	794.51
1978	119.30	94.81	409.51	196.42	820.04
1979	120.99	97.20	418.42	201.68	838.29
1980	122.56	99.79	430.26	207.08	859.69
1981	124.20	102.51	443.40	212.57	882.68
1982	125.51	106.58	463.97	217.42	913.48
1987	132.45	122.31	580.56	246.91	1082.23
1992	139.10	132.04	649.22	280.02	1200.38

* Includes petrochemical feedstocks, asphalt, lubricating oils and greases, and unforeseen requirements.

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TABLE 10.3

FORECAST TOTAL ENERGY REQUIREMENTS BY FUEL TYPE*
(Quadrillion Joules)

(Best Estimate Forecast)

	Purch. Elec.**	Natural Gas**	R.P.P.	L.P.G.	Coal	Hog Waste Fuel/Liquors	Hydro-Self Generation	Total
1977	98.77	154.39	345.51	9.61	6.52	150.98	28.73	794.51
1978	103.80	161.02	358.44	9.77	6.66	151.42	28.60	819.71
1979	105.96	162.49	365.21	9.85	6.74	157.34	29.31	836.90
1980	107.69	167.04	372.37	9.88	6.82	161.89	30.03	855.72
1981	111.54	171.58	276.42	10.03	7.21	170.52	30.39	877.69
1982	118.66	180.99	381.46	10.19	7.04	175.32	31.83	905.49
1987	140.71	193.84	404.98	10.74	8.29	221.50	37.17	1,017.23
1992	161.03	213.93	441.05	11.39	27.54	253.07	40.18	1,148.19

* Totals include allowances for unforeseen loads, petrochemical feedstock requirements, asphalt and lubricating oils and greases.

** Excludes transmission losses.

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TABLE 10.4

FORECAST TOTAL ENERGY REQUIREMENTS BY FUEL TYPE*
(Quadrillion Joules)

(High Growth Forecast)

	Purch. Elec.**	Natural Gas**	R.P.P.	L.P.G.	Coal	Hog Waste Fuel/Liquors	Hydro-Self Generation	Total
1977	98.77	154.39	345.51	9.61	6.52	150.98	28.73	794.51
1978	103.95	161.17	358.47	9.77	6.66	151.42	28.60	820.04
1979	106.56	163.14	365.33	9.87	6.74	157.34	29.31	838.29
1980	109.08	168.90	373.04	9.95	6.82	161.89	30.03	859.71
1981	113.28	173.16	378.03	10.09	7.21	170.52	30.39	882.68
1982	120.68	183.35	384.98	10.27	7.04	175.32	31.83	913.47
1987	146.38	200.48	431.26	10.95	8.29	247.74	37.17	1,082.27
1992	169.02	221.08	477.88	11.60	27.54	253.07	40.18	1,200.37

* Total includes allowance for unforeseen requirements, petrochemical feedstocks, asphalt, and lubricating oils and greases.

** Excludes transmission losses.

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TABLE 10.5

FORECAST TOTAL ENERGY REQUIREMENTS BY FUEL TYPE*

(Quadrillion Joules)

(Coal Potential, Best Estimate Scenario)

	Purch. Elec.**	Natural Gas**	R.P.P.	L.P.G.	Coal	Hog Waste Fuel/Liquors	Hydro Self-Generation	Total
1977	98.77	154.39	345.51	9.61	6.52	150.98	28.73	794.51
1978	103.80	161.02	358.44	9.77	6.66	151.42	28.60	819.71
1979	105.96	162.49	365.21	9.85	6.74	157.34	29.31	836.90
1980	107.69	166.97	372.25	9.88	7.07	161.89	30.03	855.78
1981	111.54	168.51	376.19	10.03	10.41	170.52	30.39	877.59
1982	118.66	178.31	381.08	10.19	10.23	175.32	31.83	905.62
1987	140.71	175.95	402.32	10.74	31.47	221.50	37.17	1,019.86
1992	161.03	192.75	437.92	11.39	54.80	253.07	40.18	1,151.14

* Totals include allowance for unforeseen requirements, petrochemical feedstocks, asphalt, and lubricating oils and greases.

** Excludes transmission losses.

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purchased electricity, coal and hog fuel increase from 12.4 percent, .8 percent, and 6.4 percent in 1977 to 14.0 percent, 2.4 percent and 10.1 percent in 1992, respectively. Petroleum products share, however, is forecast to decline from 43.5 percent in 1977 to 38.4 percent in 1992. All other fuels are forecast to maintain their current fuel share over the forecast period.

CHAPTER 11

ENERGY SUPPLY

This chapter deals with the extent to which petroleum products, natural gas and electricity will be available over the forecast period to fulfill likely future energy requirements, as forecast in the preceding chapters.

The future supply of other energy sources, such as hog fuel and coal, have not been explicitly forecast. In the case of hog fuel, maximum utilization excluding waste liquors is forecast at 115.5 quadrillion joules or approximately 6.8 million gravity packed units in 1992. By way of contrast, a recent study has estimated production of hog fuel in British Columbia at 10.9 million units in 1976, 11.6 million units in 1980 and 13.1 million units in 2000.[1] In the case of coal, the major question does not concern the extent of the province's resources, but rather the rate at which that resource will be developed. The rate of development, in turn, depends largely on the price of coal relative to other hydrocarbon fuels. Hence, aside from questions concerning the timing of industrial and resource development, it is safe to say that over the period considered in this report, supplies of coal will be adequate to meet demand.

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[1] *British Columbia Wood Waste Energy Co-Ordinating Committee, Hog Fuel Availability in British Columbia, 1978.*

Included in this chapter, therefore, are supply forecasts for those energy sources whose supply/demand balance is of critical concern over the forecast period.

I. Crude Oil and Natural Gas Liquids

The forecast of crude oil and natural gas liquids supply contained herein is that of the British Columbia Ministry of Mines and Petroleum Resources.[2]

The oil production rate from presently known pools is predicted to fall from 6,010 cubic metres per day in 1977 to 2,700 cubic metres per day in 1987. Over the period 1978 to 2002, the Ministry expects production from future oil discoveries to rise from 126 cubic metres per day in 1978 to a peak of 2,620 cubic metres per in 1986, falling slightly to 2,430 cubic metres per day in 1987.

Potential oil was estimated in two categories--additional oil from modifications to existing waterflood projects, and additional oil from possible tertiary applications. Additional oil from existing wells is predicted to increase 29,000 cubic metres in 1979 up to 64,000 cubic metres in 1981 and to fall off to 6,000 cubic metres by 1987. No additional oil production from modifications to existing floods is expected after 1988. By 1988, additional oil from tertiary recovery schemes is estimated to be 155,000 cubic metres and by 1992, 476,000 cubic metres.

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[2] *Ministry of Mines and Petroleum Resources, Submission to British Columbia Energy Commission Oil and Gas Price Inquiry, June 5, 1978*

Finally, the production rate of natural gas liquids is forecast to decline fairly steadily over the forecast period from 1,120 cubic metres per day in 1977 to 493 cubic metres per day in 1992.

Table 11.1 contains the forecast of production of crude oil and natural gas liquids in British Columbia over the period 1977 to 1992.

II. Natural Gas

The assured supply of natural gas to British Columbia (for fulfillment of both its domestic and export commitments) consists of the following components:

i) natural gas from reserves in British Columbia;

ii) natural gas from reserves in the Yukon and Northwest Territories;

iii) natural gas from Alberta under contract to British Columbia for both domestic and export customers.

TABLE 11.1

FORECAST PRODUCTION OF LIQUID HYDROCARBONS IN BRITISH COLUMBIA 1977-1992

(Million Cubic Metres)

	Established Oil	Discoveries	Potential Oil[1]	Total Crude Oil Supply	Natural Gas Liquids[2]	Total Supply of Liquid Hydrocarbons
1977	2.194	-	-	2.194	.407	2.601
1978	2.118	.046	-	2.164	.371	2.535
1979	1.932	.133	.029	2.094	.377	2.471
1980	1.845	.244	.046	2.135	.360	2.495
1981	1.799	.389	.064	2.252	.348	2.600
1982	1.654	.580	.058	2.292	.325	2.617
1983	1.515	.749	.046	2.310	.319	2.629
1984	1.381	.870	.035	2.286	.302	2.588
1985	1.219	.952	.017	2.188	.279	2.467
1986	1.097	.958	.012	2.067	.267	2.334
1987	.987	.888	.006	1.881	.250	2.131
1988	.882	.795	.162	1.839	.232	2.071
1989	.801	.679	.157	1.637	.226	1.863
1990	.725	.569	.319	1.613	.209	1.822
1991	.662	.476	.319	1.457	.191	1.648
1992	.609	.395	.476	1.480	.180	1.660

[1] *Modifications to existing floods and tertiary recovery schemes.*

[2] *Includes Pentanes, butanes and propanes.*

SOURCE: Ministry of Mines and Petroleum Resources

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It is recognized that the last two components of the natural gas supply are significant and important if the province is to meet its export commitment. However, to analyze the extent to which the province is or will be self-sufficient with regard to natural gas supply, only the supply of natural gas from British Columbia reserves is examined.

As in the case of the crude oil forecast, the Commission has not made its own forecast but has adopted the forecast prepared by the Ministry of Mines and Petroleum Resources.

Over the period 1977 to 1992 the forecast of annual residue gas production from known reserves goes from 8.78 billion cubic metres to 5.46 billion cubic metres, reaching a peak in 1980 at 10.56 billion cubic metres. With regard to new discoveries, it was considered that present levels of drilling activity may continue through to 1980 and accordingly, an annual addition to raw gas reserves of 15.5 billion cubic metres was estimated. Thereafter it was believed that drilling activity may slacken and that an annual addition of 10.6 billion cubic metres would be reasonable based on the average results of 1968 to 1975. Production from new discoveries is predicted to increase from .55 billion cubic metres per year in 1980 to 6.12 billion cubic metres per year in 1992. By the end of the forecast period, over 50 percent of the forecast natural gas production will be coming from new discoveries.

TABLE 11.2

FORECAST OF RESIDUE GAS PRODUCTION FROM RESERVES WITHIN BRITISH COLUMBIA

(Billion Cubic Metres)

	From Known Reserves	From Discoveries	Total
1977	8.775	-	8.775
1978	9.023	-	9.023
1979	9.391	-	9.391
1980	10.564	.554	11.118
1981	10.386	.554	10.940
1982	10.241	.839	11.080
1983	9.950	1.546	11.496
1984	9.388	2.255	11.643
1985	8,795	2.738	11.533
1986	8.246	3.222	11.468
1987	7.619	3.705	11.324
1988	7.243	4.188	11.431
1989	6.805	4.669	11.474
1990	6.342	5.152	11.494
1991	5.875	5.635	11.510
1992	5.457	6.118	11.575

Source: Ministry of Mines and Petroleum Resources

III. Electricity

The total electric generating capacity in British Columbia, as of March 31, 1978, was 9506.4 megawatts. This capacity is owned by three utilities--B.C. Hydro and Power Authority, West Kootenay Power and Light and the City of Nelson--and a large number of industrial companies. Table 11.3 contains a breakdown of this installed generation capacity.

B.C. Hydro owns the largest proportion of capacity (79 percent), followed by Alcan and Cominco with 8.6 and 6.4 percent respectively. With the exception of these two companies, the largest proportion of industrial capacity is owned by companies engaged in the forest industry and in the mining industry.

The province is primarily served by the transmission systems of B.C. Hydro and West Kootenay Power and Light.[3] In addition, there are a number of isolated areas served by small hydro plants and diesel electric facilities. The total capacity of these small non-integrated systems is 80 MW. Usually, these isolated systems are integrated with the main system when it is economic to construct the required transmission facilities.

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[3] *West Kootenay Power and Light serves an area bound approximately by Kelowna on the north, Creston and Princeton to the east and the west respectively, and by the international border to the south.*

TABLE 11.3

PRINCIPAL PRODUCERS OF ELECTRIC POWER IN BRITISH COLUMBIA, MARCH 31, 1978

	Installed Capacity (MW)	Hydro	Thermal
Utilities			
B.C. Hydro & Power Authority	7496.9	6204.4	1292.5
City of Nelson	8.7	8.7	-
West Kootenay Power & Light	42.0	42.0	-
Industries			
Alcan	817.8	812.8	5.0
Cominco	611.7	611.7	-
Forest Industries	413.6	92.5	321.1
Mining Industries	63.3	3.3	60.0
Other	52.4	.4	52.0
	9506.4	7775.8	1730.6

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Integration benefits system operation by improving reliability and reducing general requirements through improved utilization of generating facilities. It also helps to conserve fossil fuels by reducing the amount of spillage under high water conditions.

B.C. Hydro currently has three hydro projects--Site One, Seven Mile and Revelstoke--under construction. These three projects have a combined authorized capacity of 4210 MW.

In future, generation capacity expansion will be mainly in the B.C. Hydro system. There are potentially more than 20,000 MW of hydro capacity and more than 6000 MW of coal-fired thermal capacity available for development in the province. Since only a fraction of this capacity will be required over the forecast period, the province has considerable flexibility in designing generation plans which will minimize financial and environmental costs.

Table 11.4 summarizes potential supply of electricity from the B.C. Hydro integrated system based on existing facilities and projects under construction. Since electricity generation is largely from hydro sources, two estimates of supply or capability have been provided, one based on average stream flow and the other based on a stream flow equivalent to the average available over the lowest sequential five years of recorded stream flows. While the capability of the Burrard station is included in the latter estimate, the following are excluded:

i) the capability of gas turbines providing peak power to the system;

ii) electricity supplied by isolated units;

iii) electricity supplied by other utilities or from industrial self-generation.

Table 11.4 indicates that under critical supply conditions, capability of the integrated system with Burrard will reach 166.2 quadrillion joules or 46.2 billion kilowatt hours when the first three units of the Revelstoke project come on stream in 1983. Under average stream flows, capability will be approximately 161.2 quadrillion joules or 44.8 billion kilowatt hours.

TABLE 11.4

ESTIMATED SUPPLY OF ELECTRICITY FROM B.C. HYDRO INTEGRATED SYSTEM[1]

(Quadrillion Joules)

	Hydro			Critical Capability plus Burrard[3]
	Critical Capability	Average Capability	Burrard[2]	
1978	99.9	109.9	19.9	119.8
1979	111.3	121.2	19.9	131.2
1980	121.4	132.6	19.9	141.3
1981	121.4	132.6	19.9	141.3
1982	121.4	132.6	19.9	141.3
1983+	146.3	161.2	19.9	166.2

1. Based on following start-up dates

Peace Canyon (Site One)	1979 (2 units)	1980 (2 units)
Seven Mile	1980 (3 units)	
Revelstoke	1983 (3 units)	1984 (1 unit)

2. 900 MW capacity at 70 percent utilization

3. Excludes gas turbines and isolated units.

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CHAPTER 12

SUPPLY/DEMAND BALANCE

This Chapter compares the high forecasts of energy requirements from Chapter 10 with the projected availability discussed in Chapter 11, for refined petroleum products, natural gas, and electricity. Keeping in mind the accuracy of any long term forecasts of supply or requirements, the following comparisons are meant only to indicate the existence and approximate magnitude of a surplus or deficit in the case of oil or gas; or the approximate required rate of expansion of electricity capability.

I. Refined Petroleum Products

Table 12.1 compares the projected total supply of liquid hydrocarbons from Table 11.1 with the forecasts of requirements from Tables 10.3, 10.4, and 10.5. On the basis of this comparison, it is evident that the deficit which exists now will continue to worsen over the forecast period, to the extent that by 1992, British Columbia will likely be supplying about 13 to 14 percent of its total projected requirement for refined petroleum products from indigenous sources. The current deficit of 71 percent is expected to rise to between 86 and 87 percent by 1992.

TABLE 12.1

LIQUID HYDROCARBON SUPPLY/DEMAND BALANCE
(Quadrillion joules)

	Total Supply of Liquid Hydrocarbons[1]	Requirements for Liquid Hydrocarbons[2]			Surplus (Deficit)		
		High	Best Est.	Coal Conv.	High	Best Est.	Coal Conv.
1977	101.78	355.12	355.12	355.12	(253.34)	(253.34)	(253.34)
1978	99.13	368.24	368.21	368.21	(269.11)	(269.08)	(269.08)
1979	96.69	375.20	375.06	375.06	(278.51)	(278.37)	(278.37)
1980	97.63	382.99	382.25	382.13	(285.36)	(284.62)	(284.50)
1981	101.74	388.12	386.45	386.22	(286.38	(284.71)	(284.48)
1982	102.40	395.25	391.65	391.27	(292.85)	(289.25)	(288.87)
1987	83.39	442.21	415.72	413.06	(358.82)	(332.33)	(329.67)
1992	64.96	489.50	452.44	449.31	(424.54)	(387.48)	(384.35)

1. From Table 11.1, using a conversion factor of 39.13 billion joules/m^3. Includes liquid petroleum gases from natural gas stream.
2. From Tables 10.3, 10.4, and 10.5. Includes liquid petroleum gases.

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II. Natural Gas

Table 12.2 compares the estimated natural gas requirements forecasts from Tables 10.3, 10.4, and 10.5 with the projected supply of natural gas from Table 11.2. While making these comparisons, only the supply from domestic resources is considered. The supply from Alberta and from reserves in the Yukon and Northwest Territories is significant and important if the province is to meet its export commitment. However, because of the difficulty in forecasting future export volumes,[1] only the domestic supply is considered, to analyze the extent to which the province is or will be self-sufficient with regard to natural gas supply. Requirements for the Columbia Natural Gas Ltd. franchise area, which is currently supplied with natural gas from Alberta, are included in Table 12.2.

The volumes indicated to be in excess of immediate British Columbia requirements range from 203 quadrillion joules to 231 quadrillion joules in 1992, compared to 167 quadrillion joules in 1977. This estimate of surplus, however, does not explicitly evaluate the issue of transmission/distribution capacity and peak day requirements, especially under circumstances when daily deliveries under export licence GL-41 are at the maximum permitted under the contract.

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[1] *For a discussion of possible future export volumes, see Province of British Columbia Submission to 1978 National Energy Board Inquiry into Current and Future Natural Gas Supply and Requirements in Canada, (October 6, 1978), pp 14-20.*

TABLE 12.2

NATURAL GAS SUPPLY/DEMAND BALANCE
(Quadrillion joules)

	Domestic Supply of Natural Gas[1]	Domestic Requirements[2]			Pipeline Fuel and Losses	Volume in Excess of Immediate Domestic Requirements		
		High	Best Est.	Coal Conv.		High	Best Est.	Coal Conv.
1977	326.96	154.39	154.39	154.39	5.40	167.16	167.16	167.16
1978	336.19	161.17	161.02	161.02	5.64	169.38	169.53	169.53
1979	349.90	163.14	162.49	162.49	5.69	181.07	181.72	181.72
1980	414.25	168.90	167.04	166.97	5.85	239.50	241.36	241.43
1981	407.61	173.16	171.58	168.51	6.01	228.44	230.02	233.09
1982	412.83	183.35	180.99	178.31	6.33	223.15	225.51	228.19
1987	421.92	200.48	193.84	175.95	6.78	214.66	221.30	239.19
1992	431.27	221.08	213.93	192.75	7.49	202.70	209.85	231.03

1. From Table 11.2, using a conversion factor of 37.259 million joules/m^3.

2. From Tables 10.3, 10.4, and 10.5, no allowance has been made for natural gas being burned at Burrard thermal plant.

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III. Purchased Electricity

This report forecasts purchased electricity demand to grow at an annual compound rate of between 3.3 and 3.7 percent. Although utilities other than B.C. Hydro currently supply 5.5 quadrillion joules or approximately 5 percent of existing requirements, the following supply/demand balance takes into account only B.C. Hydro's system requirements, assuming for purposes of simplicity that other utilities do not meet any additional requirements beyond 5.5 quadrillion joules during the forecast period.

Two separate supply cases for both high and best estimate scenarios are considered. In Case I, Table 12.3, electricity supply is shown as B.C. Hydro's average hydro-electric capability only. No thermal electric capacity is included in this instance. For Case II, Table 12.4, B.C. Hydro critical capability, together with the Burrard thermal plant is given as supply. In both Case I and Case II, a deficit situation does not occur until after 1988 at the earliest (see Figure 1.2). Prior to that time, surpluses range from .62 quadrillion joules to 27.87 quadrillion joules.

Tables 12.3 and 12.4 both understate the nature of the surplus of B.C. Hydro, since the entire increment to capability between 1982 and 1987 occurs in 1983, when the first three units of Revelstoke are due on line.

TABLE 12.3

B.C. HYDRO ELECTRICITY SUPPLY/DEMAND BALANCE

CASE I
(Quadrillion Joules)

	B.C. Hydro Supply[1] (Average hydro-electric capability)	B.C. Hydro Gross Requirements[2]		Surplus (Deficit)	
		High	Best Est.	High	Best Est.[3]
1978	109.9	109.28	109.11	.62	.79
1979	121.2	112.18	111.51	9.02	9.69
1980	132.6	114.97	113.43	17.63	19.17
1981	132.6	119.64	117.70	12.96	14.90
1982	132.6	127.85	125.61	4.75	6.99
1987	161.2	156.38	150.08	4.82	11.12
1992	161.2	181.57	172.64	(20.37)	(11.44)

1. No allowance for thermal plants.
2. Includes adjustment for system losses.
3. With and without coal conversion.

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TABLE 12.4

B.C. HYDRO ELECTRICITY SUPPLY/DEMAND BALANCE

CASE II
(Quadrillion Joules)

	B.C. Hydro Supply[1] (Critical Capability)	B.C. Hydro Gross Requirements[2]		Surplus (Deficit)	
		High	Best. Est.	High	Best Est.[3]
1978	119.8	109.28	109.11	10.52	10.69
1979	131.2	112.18	111.51	19.02	19.69
1980	141.3	114.97	113.43	26.33	27.87
1981	141.3	119.64	117.70	21.66	23.60
1982	141.3	127.85	125.61	13.45	15.69
1987	166.2	156.38	150.08	9.82	16.12
1992	166.2	181.57	172.64	(15.37)	(6.44)

1. Includes Burrard at 70 percent utilization. Excludes other thermal peaking and isolated facilities.
2. Includes adjustment for system losses.
3. With and without coal conversion.

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APPENDIX A

REFINED PETROLEUM PRODUCTS FORECAST
1978-1992

I. Introduction

Refined Petroleum Products comprise about 45 percent of the energy used in this province, and are directed to a wide range of end uses. In this appendix, the Refined Petroleum Products forecast is disaggregated in terms of particular fuels in the four end use sectors.

The Refined Petroleum Products (RPP) forecast is based on the total RPP best estimate forecast presented in the preceding chapters and is therefore entirely dependent on the assumptions and conclusions contained therein. To forecast requirements for particular products, the historical proportion of total RPP captured by each specific fuel has been used as the basis for projection. Where it can be anticipated that these proportions will change over time, the changes have been incorporated into the forecast. Underlying this forecast is the assumption implicit in this report that relative prices among various RPP's will remain as they were in the recent past. The earlier aggregated RPP forecast on which this detailed outlook is based has accounted for competition between RPP's and other fuels. It is assumed that relative prices will not change sufficiently to effect a change in consumption patterns.

Since the oil embargo in 1973-74, there has been a conscious effort on the part of Canadians to conserve energy in general, and in particular to reduce the consumption of petroleum products. In British Columbia, the forest industry has been moving towards energy self-sufficiency by using wood-waste or hog fuel to replace the use of heavy fuel oil. In future, some petroleum product consumption may be displaced through conversion to coal by industrial users. The combined effect of these moves has been discussed in preceding chapters. In general, it is forecast that the use of Refined Petroleum Products in total will not increase as rapidly as total energy requirements.

II. Residential Sector

In 1976, light fuel oil (furnace oil) accounted for 83.6 percent of total Refined Petroleum Products consumption in the residential sector. Kerosene and stove oil accounted for 14.5 percent, while heavy fuel oil accounted for slightly less than 2 percent. Over the period 1973-1976 inclusive, these percentages have been relatively steady. Furnace oil has increased its share slightly, while both kerosene and heavy fuel oil have decreased slightly.

Stove oil accounts for the majority of the total kerosene and stove oil consumption and is used mainly in

TABLE A1

FUTURE CONSUMPTION OF REFINED PETROLEUM PRODUCTS IN THE RESIDENTIAL SECTOR

	Kerosene & Stove Oil		Light Fuel Oil		Heavy Fuel Oil		Total[1]	
	000 Bbls.	000 M^3	000 Bbls.	000 M^3	000 Bbls.	000 M^3	000 Bbls.	000 M^3
1977	752	120	4418	702	97	15	5267	837
1978	745	118	4378	696	96	15	5219	830
1979	731	116	4295	683	95	15	5121	814
1980	717	114	4211	669	93	15	5021	798
1981	703	112	4128	656	91	14	4922	783
1982	689	110	4044	643	89	14	4822	767
1987	574	91	3671	584	80	12	4325	688
1992	470	75	3298	524	71	11	3839	610

[1] *Errors in the totals due to rounding.*

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northern communities where furnace oil is not acceptable due to its higher pour point. Stove oil is generally about 1.1 to 1.3 cents per litre (5 to 6 cents per gallon) more expensive than furnace oil and is, therefore, not consumed if furnace oil can be substituted. Heavy fuel consumed for residential purposes is used by large apartments on Vancouver Island. The characteristics of heavy fuel oil are such that it is not usable in small furnaces despite its price advantage over furnace oil.

Over the forecast period, therefore, it is expected that furnace oil will continue to be the major source of refined products consumed in the residential sector. In fact, the proportion of residential RPP demand that is met by furnace oil will be greater in 1992 than in 1978 as the use of stove oil and heavy fuel oil in this sector will decline more rapidly than total RPP demand.

The resulting forecast of petroleum products consumed in the residential sector is shown in Table Al.

III. Commercial Sector

The commercial sector comprises agriculture, construction, government and commercial heating. The agriculture subsector, which consumes only diesel fuel and gasoline, has grown in recent years to become the largest component of the commercial sector, followed by commercial heating. Construction has steadily declined from the largest component in 1973 to third place in 1976. It is not known if this trend will continue.

The forecast of petroleum products used in the commercial sector was based on the trend in the proportion that each petroleum product held in each of the subsectors. In commercial heating, excluding government, light fuel oil is expected to increase its proportion of the total petroleum product consumption to over 75 percent by 1992. It is expected that heavy fuel oil will account for most of the remainder, with stove oil holding a residual share. As in the residential sector, light fuel oil will be the petroleum product of first choice in the commercial heating sector. Heavy fuel oil consumption will increase slightly in absolute terms but will decline relative to light fuel oil.

In agriculture, it is expected that gasoline will continue to be the predominant fuel but it is assumed that an increasing proportion of new farm vehicles will be diesel powered because of economy and efficiency.

In the government subsector, heavy fuel oil is expected to decrease its share of consumption but will still represent more than 50 percent of total consumption. Government buildings on Vancouver Island in particular are expected to continue using heavy fuel oil for heating. Light fuel oil will account for most of the remaining requirements, with stove oil being used mainly in outlying areas where other heating products are not available. Government use of diesel fuel and gasoline is included in the transportation sector.

The construction subsector consumes a wide range of petroleum products for a variety of uses. In 1976, diesel fuel accounted for over 60 percent of total refined products in this subsector and it is expected to continue to do so over the forecast period. Diesel is used mainly to power construction machinery. Gasoline, which is used for similar purposes, is expected to account for 20 percent of this subsector over the forecast period.

The forecast of Refined Petroleum Products consumed in the commercial sector is shown in Table A2.

IV. Industrial Sector

The industrial sector comprises forestry (logging, wood industries and pulp and paper), mining and primary metals, other industrial (cement manufacture, glass, food and beverage, chemical and chemical products, and other manufacturing). Oil refining has not been included in this fuel split analysis for the industrial sector, but rather under other uses. Table A3 summarizes requirements in this sector by product type.

TABLE A2

FUTURE CONSUMPTION OF REFINED PETROLEUM PRODUCTS IN THE COMMERCIAL SECTOR

	Motor Gasoline		Diesel Fuel		Kerosene & Stove Oil		Light Fuel Oil		Heavy Fuel Oil		Total[1]	
	000 Bbl	000 M^3	000 Bbl	000 M^3	000 Bbl	000 M^3	000 Bbl	000 M^3	000 Bbl	000 M^3	000 Bbl	000 M^3
1977	1360	216	1286	204	100	16	1192	190	687	109	4625	735
1978	1390	221	1336	212	102	16	1230	196	696	111	4754	756
1979	1420	226	1390	221	104	17	1250	199	719	114	4883	776
1980	1450	231	1445	230	106	17	1285	204	730	116	5016	797
1981	1495	238	1495	238	108	17	1315	209	753	120	5166	821
1982	1540	245	1565	249	95	15	1365	217	778	124	5343	849
1987	1735	276	1965	312	99	16	1595	254	858	136	6252	994
1992	2005	319	2335	371	101	16	1740	277	954	151	7135	1134

[1] *Errors in the totals due to rounding.*

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TABLE A3

FUTURE CONSUMPTION OF REFINED PETROLEUM PRODUCTS IN THE INDUSTRIAL SECTOR

	Motor Gasoline		Kerosene & Stove Oil		Diesel Fuel		Light Fuel Oil		Heavy Fuel Oil		Total[1]	
	000 Bbl	000 M^3	000 Bbl	000 M^3	000 Bbl	000 M^3	000 Bbl	000 M^3	000 Bbl	000 M^3	000 Bbl	000 M^3
1977	905	144	277	44	3139	499	755	120	5553	883	10,629	1690
1978	976	155	287	46	3398	540	690	110	5870	933	11,221	1784
1979	983	156	266	42	3413	543	602	96	5994	953	11,258	1790
1980	993	158	259	41	3430	545	603	96	6097	969	11,382	1810
1981	1021	162	267	42	3527	561	619	98	5685	904	11,119	1768
1982	1050	167	278	44	3638	578	636	101	5608	892	11,210	1782
1987	1211	193	336	53	4246	675	719	114	5371	854	11,883	1889
1992	1358	216	378	60	4781	760	795	126	5549	882	12,861	2045

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[1] *Errors in the totals due to rounding.*

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The forest sector is the largest industrial consumer of Refined Petroleum Products, consuming over 75 percent of that sector's demand. Heavy fuel oil, used largely for boiler fuel, has historically been the main RPP used in the forest sector, comprising nearly 70 percent of the forest sector's RPP consumption. The demand for heavy fuel oil will decline after 1981 when hog fuel burners presently being installed come into use. However, heavy fuel oil will continue to be the main RPP used in the forest sector throughout the forecast period. Diesel fuel is basically used in the logging industry to power log handling machinery and logging trucks. Although it is expected that logging will take place in more remote areas, conservation measures such as lighter trucks and more efficient engines are assumed to offset increased requirements per unit of output.

The mining and primary metals subsector comprises about 15 percent of the industrial use of refined petroleum products. Diesel fuel is the largest component of this consumption, constituting over 50 percent in recent years. Although there may be some displacement of RPP by natural gas and coal, diesel fuel is used in internal combustion engines and therefore will continue to supply an important part of the mining industry's energy demand.

Other industrial uses of RPP comprise less than 10 percent of the total consumption. Statistics Canada does not enter motor gasoline and diesel fuel under its "other industrial" heading. Therefore, this forecast considers only heating and heavy fuel oils in other industrial uses. Since this category comprises such a wide variety of industries, it is impossible to make useful generalizations about the outlook for RPP demand. Shares for each type of fuel have therefore been held constant over the forecast period.

V. Transportation

The product forecast for passenger vehicles assumes that the voluntary guidelines for the federal government (EPA fleet ratings) will be met to 1985. It is also forecast that the introduction of diesel passenger automobiles will take hold in 1981 with 1 percent of new car sales in that year being diesel powered. By 1990 it is assumed that a 10 percent market share of new car sales is obtained. While diesel powered vehicles might be expected to be more efficient than motor gasolines counterparts, no specific economies are included in the forecast.

For commercial vehicles, the use of diesel fuel in trucking has grown very rapidly during the 1970's. The Canadian Trucking Association has predicted continued inroads by diesel fuel in all forms of trucking, including light trucks. Therefore, this forecast assumes that the historic growth in market share of diesel powered vehicles will continue through the forecast period. The actual split between engine types that will occur depends on relative efficiencies obtained over time. Rapid technological advancements are expected, but at this time it is difficult to determine which fuel type will be favoured by lighter vehicles. The forecast growth in diesel fuel, if in error, likely overstates actual conversion which might take place.

Total sales of aviation gasoline have been declining over the past decade as the large airlines have retired propellor aircraft in favour of jet and turbopropellor aircraft. This conversion is now virtually complete and therefore sales of aviation gasoline will likely remain relatively stable in the future. The relatively strong growth within the industry will require a corresponding growth in turbo fuel supply.

Marine transport fuel consumption includes consumption of heavy fuel oil and diesel fuel oil by Canadian and foreign shipping companies. The very large ships tend to use heavy fuel oil with lighter vessels using diesel fuel. Heavy fuel oil consumption is projected to remain relatively constant throughout the forecast period, with diesel fuel oil consumption

TABLE A4

FUTURE CONSUMPTION OF REFINED PETROLEUM PRODUCTS IN THE TRANSPORT SECTOR

	Motor Gasoline		Diesel Fuel		Aviation Gasoline		Turbo Fuel		Heavy Fuel Oil		Total[1]	
	000 Bbl	000 M^3	000 Bbl	000 M^3	000 Bbl	000 M^3	000 Bbl	000 M^3	000 Bbl	000 M^3	000 Bbl	000 M^3
1977	21,540	3425	7183	1142	238	38	2912	463	1239	197	33,112	5264
1978	22,270	3541	7609	1210	238	38	3026	481	1256	200	34,399	5469
1979	22,661	3603	7983	1269	238	38	3145	500	1275	203	35,302	5613
1980	22,992	3655	8378	1332	238	38	3269	520	1294	206	36,171	5751
1981	23,225	3692	8756	1392	238	38	3397	540	1314	209	36,930	5871
1982	23,130	3677	9196	1462	238	38	3532	562	1335	212	37,431	5951
1987	21,509	3420	11,888	1890	238	38	4208	669	1446	230	39,289	6246
1992	20,572	3271	15,301	2433	238	38	4898	779	1567	249	42,576	6769

[1] *Errors in the totals due to rounding.*

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increasing in proportion to growth in domestic trade. All consumption by provincial ferries is allocated to diesel fuel.

Energy consumption in the rail transport industry has been predominantly diesel fuel, with some heavy fuel oil and crude oil. Canadian National Railways and CP Rail locomotives use diesel fuel. It is assumed that growth in energy consumption will be captured entirely by diesel fuel; no allowance is made for possible electrification of mainline routes during the forecast period.

The forecast fuel consumption is based on projections of growth in major products transported by rail. It is noted, however, that the railways are currently facing capacity constraints on main lines through the mountains, which could constrain growth in the future. As a counterweight, the port of Prince Rupert may be expanded so that growth may be unimpaired.

Table A4 summarizes RPP requirements by fuel in the transport sector.

VI. Other Uses

Other uses of petroleum products include asphalts, lubricating oils, petrochemical feedstock, refinery own use, and other products such as waxes. Table A5 summarizes requirements for each product, based upon previous analysis.

TABLE A5

REFINED PETROLEUM PRODUCTS: OTHER USES

	Refinery Own Use[1]		Asphalt[2]		Lubricating Oil and Greases[2]		Toluene[3]		Other Products[4]		Total	
	000 BBLS	000 M^3	000 BBLS	000 M^3	000 BBLS	000 M^3	000 BBLS	000 M^3	000 BBLS	000 M^3	000 BBLS	000 M^3
1977	2549	405	1787	281	698	111	391	62	935	149	6360	1008
1978	2659	423	1878	299	724	115	403	64	950	151	6614	1052
1979	2715	432	1974	314	751	119	413	66	965	153	6818	1084
1980	2776	441	2074	330	780	124	426	68	980	156	7036	1119
1981	2809	447	2180	347	809	129	439	70	996	158	7233	1151
1982	2850	453	2291	364	840	134	452	72	1012	161	7445	1184
1987	2857	454	2939	467	1013	161	498	79	1095	174	8402	1335
1992	2929	466	3769	599	1220	194	550	87	1186	189	9654	1535

[1] *Still gas and other products. Table 5.42*

[2] *Table 7.2*

[3] *Table 7.3*

[4] *Excludes coke and liquified petroleum gases. Forecast to increase at 1.6 per cent per annum.*

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VII. Conclusions

Refined Petroleum Products will continue to have a major part in the supply of energy to British Columbia. The RPP share of total energy demand under the best estimate forecast is projected to decline from 45 percent in 1976 to 38 percent in 1992. However, the various fuels will be affected differently. Furnace and stove oil will generally decline in their use for space heating applications and will be replaced by natural gas. Diesel fuel demand, on the other hand, is expected to increase dramatically over the forecast period as transport and other demands increase. The increase in requirements for diesel and for turbo fuel will alter the ratio between gasoline and distillates from 1.1/1.0 in 1977 (forecast numbers) to 0.7/1.0 in 1992. Heavy fuel oil will continue its important role in industrial uses, although its demand will increase only slightly over the forecast period. Motor gasoline will decline slightly after the early 1980's as changes in the provincial automobile fleet take effect.

Assuming 100 percent capacity utilization in existing B.C. refineries and allowing for approved expansions, British Columbia could produce 10.5 million cubic meters (66.05 million barrels) of RPP by 1992. The RPP forecast indicates that B.C. will require 12.2 million cubic meters (76.7 million barrels) of RPP in 1992, of which 1.1 million cubic meters

(6.9 million barrels) will be imported mostly from Alberta. Tables A6 and A7 indicate total RPP demand by product for forecast period, including refinery own use and non-energy uses.

TABLE A6

FUTURE CONSUMPTION OF REFINED PETROLEUM PRODUCTS IN ALL SECTORS

(Thousands of Barrels)

	Avgas	Mogas	Turbo	Kero	Diesel	Light	Heavy	Other[1]	Total[2]
1977	238	23,805	2912	1129	11,608	6365	7576	6360	59,993
1978	238	24,636	3026	1134	12,343	6298	7918	6614	62,207
1979	238	25,064	3145	1101	12,786	6147	8083	6818	63,382
1980	238	25,435	3269	1082	13,253	6099	8214	7036	64,626
1981	238	24,741	3397	1078	13,778	6062	7843	7233	65,370
1982	238	25,720	3532	1062	14,399	6045	7810	7445	66,251
1987	238	24,455	4208	1009	18,099	5985	7755	8402	70,151
1992	238	23,935	4898	949	22,417	5833	8141	9654	76,065

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[1] *Includes refinery own-use and other uses. Excludes Liquified Petroleum Gases from refinery streams.*

[2] *Errors in totals due to rounding.*

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TABLE A7

FUTURE CONSUMPTION OF REFINED PETROLEUM PRODUCTS IN ALL SECTORS

(thousand of cubic metres)

	Avgas	Mogas	Turbo	Kero	Diesel	Light	Heavy	Other[1]	Total[2]
1977	38	3785	463	180	1845	1012	1204	1008	9353
1978	38	3917	481	180	1962	1002	1259	1052	9891
1979	38	3985	500	175	2033	978	1285	1084	10,078
1980	38	4044	520	172	2107	969	1306	1119	10,275
1981	38	4092	540	171	2191	963	1247	1151	10,393
1982	38	4089	562	169	2289	961	1242	1184	10,534
1987	38	3889	669	160	2877	952	1232	1335	11,152
1992	38	3806	779	151	3564	927	1293	1535	12,093

[1] *Includes refinery own-use and other uses. Excludes Liquified Petroleum Gases from refinery streams.*

[2] *Errors in totals due to rounding.*

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APPENDIX B

APPENDIX B

International System of Units (SI)

On January 16, 1970 the move towards nation-wide adoption in Canada of the metric system was initiated when the White Paper on Metric Conversion was tabled and acclaimed by all parties in the House of Commons. In 1971 the House amended the Weights and Measures Act of 1873 to make the International System of Units (SI) legal for all purposes in Canada.

All units in the metric system are in multiples of ten and as such the system is easier to use than the currently employed Imperial system. Other advantages to the metric system include: it will enable Canada to compete more effectively in world markets where the metric system is the predominant standard of measurement; the system provides greater efficiency and simplicity in industry and the educational system; and the system provides easier comparisons for consumers.

By the end of 1979 the following industries, among others, are slated to be operating completely in SI units:

Petroleum Refineries, Wholesalers and Gasoline Service Stations

Petroleum and Natural Gas Industry & Services

Natural Gas Distribution and Transport.

Electric power utilities are scheduled to be operating in SI units early in 1980. With the energy industry on the verge of complete conversion to the metric system it was imperative for the Energy Commission to start adopting SI in its reports. Thus this edition of the energy supply and requirements forecast has been prepared using SI throughout.

Dual tables containing both the metric and Imperial units have not been included in this report in accordance with the Metric Commission of Canada's finding that:

"The most efficient way to help people think metric is to immerse them in the metric system and to avoid reference to the Imperial system of measurement. As long as the Imperial quantity is provided people will record and use this only, it is familiar and it is the easy way out."[1]

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[1] *Metric Monitor, Ottawa Canada, March 1977, p. 6.*

TABLE B.1

THE INTERNATIONAL SYSTEM OF UNITS (SI) CONVERSION TABLE

Conversion Factors			Selected Metric (SI) Unit	
Traditional Unit	Factor	E*	Name	Symbol
barrel (35 imp. gal.)	1.589 873	E-01	cubic metre	m^3
barrel per day	6.624 471	E-03	cubic metre per hour	m^3/h
BTU	1.055 056	E+00	kilojoule	kJ
degree Fahrenheit	(°F-32)(5/9)	E+00	degree Celsius	°C
foot	3.048	E-01	metre	m
gallon (imp.)	4.546 09	E+00	litre	1
gallon per mile	2.824 809	E+02	litre per 100 kilometre	1/100 km
kilowatt hour	3.6	E+03	kilojoule	kJ
Mcf (thousand cubic feet)	2.826 231	E+01	cubic metre (API)	m^3API
mile	1.609 344	E+00	kilometre	km
mile per gallon	3.540 060	E-01	kilometre per litre	km/1
ounce	2.834 952	E+01	gram	g
pound-mass	4.535 924	E-01	kilogram	kg
square foot	9.290 304	E-02	square metre	m^2
square mile	2.589 988	E+00	square kilometre	km^2
standard cubic foot	2.826 231	E-02	cubic metre API	m^3API
ton (short)	9.071 847	E-01	tonne	t
ton (long)	1.016 047	E+00	tonne	t

Prefixes

Multiplying Factor	Prefix	Symbol
1 000 000 000 000 = 10^{12}	tera	T
1 000 000 000 = 10^9	giga	G
1 000 000 = 10^6	mega	M
1 000 = 10^3	kilo	k
100 = 10^2	hecto	h
10 = 10^1	deca	da

*Multiply value in traditional units by factor x 10 = to obtain value in metric units.

To go from metric to traditional units divide by the conversion factor instead of multiplying.

APPENDIX C

TABLE C.1

VANCOUVER ISLAND CAPTURE RATES
(Percent)

Space Heating	Single Detached	Single Attached	Apartments	Mobile
No Gas Service				
Electricity	85	95	95	60
Natural Gas	-	-	-	-
RPP's	10	5	5	20
LPG's	5	-	-	20

Water Heating	Single Detached	Single Attached	Apartments	Mobile
No Gas Service				
Electricity	85	95	5	60
Natural Gas	-	-	-	-
RPP's	10	5	95	20
LPG's	5	-	-	20

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TABLE C.2

OKANAGAN-WEST KOOTENAY
CAPTURE RATES (Pre 1988)
(percent)

Space Heating	Single Detached	Single Attached	Apartments	Mobile
Gas Service				
Electricity	60	60	100	40
Natural Gas	40	40	-	60
RPP's	-	-	-	-
LPG's	-	-	-	-
No Gas Service				
Electricity	100	100	NA*	60
Natural Gas	-	-	NA	-
RPP's	-	-	NA	20
LPG's	-	-	NA	20
Water Heating				
Gas Service				
Electricity	60	60	50	40
Natural Gas	40	40	50	60
RPP's	-	-	-	-
LPG's	-	-	-	-
No Gas Service				
Electricity	100	100	NA	60
Natural Gas	-	-	NA	-
RPP's	-	-	NA	20
LPG's	-	-	NA	20

* Not Applicable

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TABLE C.3

EAST KOOTENAY CAPTURE RATES
(percent)

Space Heating	Single Detached	Attached	Apartments	Mobile
Gas Service				
Electricity	50	50	100	40
Natural Gas	50	50	-	60
RPP's	-	-	-	-
LPG's	-	-	-	-
No Gas Service				
Electricity	90	90	NA*	60
Natural Gas	-	-	NA	-
RPP's	10	10	NA	20
LPG's	-	-	NA	20

Water Heating	Single Detached	Attached	Apartments	Mobile
Gas Service				
Electricity	50	50	50	40
Natural Gas	50	50	50	60
RPP's	-	-	-	-
LPG's	-	-	-	-
No Gas Service				
Electricity	100	100	NA	80
Natural Gas	-	-	NA	-
RPP's	-	-	NA	-
LPG's	-	-	NA	20

* Not Applicable

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TABLE C.4

CARIBOO CAPTURE RATES
(Percent)

Space Heating	Single Detached	Single Attached	Apartments	Mobile
Gas Service				
Electricity	5	10	20	30
Natural Gas	95	90	80	50
RPP's	-	-	-	-
LPG's	-	-	-	20
No Gas Service				
Electricity	55	60	NA*	60
Natural Gas	-	-	NA	-
RPP's	35	40	NA	20
LPG's	10	-	NA	20
Water Heating				
Gas Service				
Electricity	5	10	-	30
Natural Gas	95	90	100	50
RPP's	-	-	-	-
LPG's	-	-	-	20
No Gas Service				
Electricity	95	100	NA	85
Natural Gas	-	-	NA	-
RPP's	-	-	NA	-
LPG's	5	-	NA	15

* Not Applicable

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TABLE C.5

OMINECA-PEACE CAPTURE RATES
(Percent)

Space Heating	Single Detached	Single Attached	Apartments	Mobile
Gas Service				
Electricity	5	10	20	30
Natural Gas	95	90	80	50
RPP's	-	-	-	-
LPG's	-	-	-	20
No Gas Service				
Electricity	55	60	NA*	60
Natural Gas	-	-	NA	-
RPP's	35	40	NA	20
LPG's	10	-	NA	20
Water Heating				
Gas Service				
Electricity	5	10	-	30
Natural Gas	95	90	100	50
RPP's	-	-	-	-
LPG's	-	-	-	20
No Gas Service				
Electricity	95	100	NA	85
Natural Gas	-	-	NA	-
RPP's	-	-	NA	-
LPG's	5	-	NA	15

* Not Applicable

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TABLE C.6

SKEENA CAPTURE RATES
(Percent)

Space Heating	Single Detached	Single Attached	Apartments	Mobile
Gas Service				
Electricity	5	10	20	30
Natural Gas	95	90	80	50
RPP's	-	-	-	-
LPG's	-	-	-	20
No Gas Service				
Electricity	55	60	NA*	60
Natural Gas	-	-	NA	-
RPP's	35	40	NA	20
LPG's	10	-	NA	20
Water Heating				
Gas Service				
Electricity	5	10	-	30
Natural Gas	95	90	100	50
RPP's	-	-	-	-
LPG's	-	-	-	20
No Gas Service				
Electricity	95	100	NA	85
Natural Gas	-	-	NA	-
RPP's	-	-	NA	-
LPG's	5	-	NA	15

* Not Applicable

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TABLE C.7

FORECAST SATURATION RATES OF MAJOR APPLIANCES
(percent)

Appliance	Actual 1977	1987 +
Refrigerator	99	99
Home Freezer	52	70
Cooking	87	87
Electric Dryer	56	70
Washer	71	75
Dishwasher	28	50
Colour TV	74	85
Black & White TV	43	30

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APPENDIX D

TABLE D1

HISTORICAL NATURAL GAS CONSUMPTION IN B.C.
(Commercial Sector)
(MMcf)

	Commercial and Industrial Use[1]	Industrial Consumption (Mining, Manufacturing and Logging)[2]	Commercial Consumption	Estimated Apartment Use[3]	Net Commercial Use
1976	97,615	58,000*	39,615	6402	33,213
1975	86,168	52,005	34,163	5934	28,229
1974	91,905	58,267	33,638	5526	28,112
1973	88,038	52,803	35,235	5118	30,117
1972	79,152	45,024	34,128	4710	29,418
1971	68,561	39,133	29,428	4362	25,066
1970	57,962	33,136	24,826	3894	20,932

1. Source: Derived using data from Statistics Canada 57-205 (Gas Utilities) and Statistics Canada 57-202 (Electric Power Utilities Vol. II); numbers do not include gas used by electric utilities for thermal generation.
2. Source: Manufacturing consumption is obtained from Statistics Canada 57-002, Mining from 26-201, Logging industry does not use significant volume of natural gas and therefore is not included.
3. Data for 1971 and 1976 was avilable from the Residential Sector, other values were intropolated.

* 1976 figure is estimated using our forecast requirements.

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TABLE **D2**

HISTORICAL ELECTRICITY CONSUMPTION IN B.C.

(Commercial Sector)

(Gwh)

	Total Commercial and Industrial Use[1] (A)	Industrial Use (Mining, Manuf., and Logging) (B)	Commercial Use and Street Lighting (C)=(A)-(B)	Street Lighting (D)	Net Commercial Use (C)-(D)
1970	19,055	15,469	3586	143	3443
1971	21,805	17,868	3934	153	3781
1972	23,448	19,038	4410	175	4235
1973	24,829	19,538	5291	171	5120
1974	24,567	18,661	5906	172	5734
1975	22,611	16,722	5889	194	5695
1976	28,296*	21,438	6858	203	6655

- Not Available.

* Includes 16,206 Gwh supplied by utilities, the remainder represents the self-generated electricity.

Industrial use includes both the purchased and self-generated electricity.

1. Source: Statistics Canada Catalogue SC 57-202 Vol. II, 1975 "Electric Power Statistics" Table 17.
2. Source: Statistics Canada Catalogue SC 57-202; additional information was obtained from Statistics Canada office in Ottawa.

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TABLE D3

HISTORICAL REFINED PETROLEUM PRODUCTS CONSUMPTION IN B.C.

(Commercial Sector)
(Thousands of Barrels)

	Motor Gasoline	Diesel Oil	Kerosene & Stove Oil	Light Fuel Oil	Heavy Fuel Oil	Total
1970	1339.0 (7.38)	1211.0 (7.45)	186.0 (1.11)	790.0 (4.86)	1361.0 (9.03)	4887.0 (29.83)
1971	1248.0 (6.88)	1447.0 (8.90)	222.0 (1.33)	880.0 (5.41)	1260.0 (8.36)	5057.0 (30.68)
1972	1239.0 (6.83)	980.0 (6.03)	197.5 (1.18)	981.0 (6.03)	1306.0 (8.66)	4703.5 (28.73)
1973	1365.7 (7.53)	1150.0 (7.07)	185.0 (1.11)	996.0 (6.12)	1336.5 (8.86)	5032.6 (30.69)
1974	1519.2 (8.37)	1159.6 (7.13)	186.0 (1.11)	1082.0 (6.65)	1313.0 (8.71)	5259.6 (31.97)
1975	1226.5 (6.76)	971.0 (5.97)	126.8 (0.76)	1188.4 (7.31)	1292.4 (8.57)	4804.8 (29.37)
1976	1263.0 (6.96)	1198.0 (7.37)	103.1 (0.62)	1123.3 (6.90)	678.1 (4.50)	4365.5 (26.35)

Note: Figures in parenthesis are in quadrillion joules.

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